YDAY HEALTH SERIES

BOOK TWO

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THE EVERYDAY HEALTH SERIES

BOOK TWO: KEEPING THE BODY IN HEALTH

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BOOK ONE: BUILDING HEALTH HABITS

BOOK TWO: KEEPING THE BODY IN HEALTH

HEALTH COMES WITH FRESH AIR AND EXERCISE.

THE EVERYDAY HEALTH SERIES

Book Two

KEEPING THE BODY IN HEALTH

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INTRODUCTION

It is the aim in The Everyday Health Series to present in an attractive form for pupils in the elementary school the latest and most accurate knowledge relating to physiology and especially to the hygiene of daily life. The constant effort of the authors has been to make scientific knowledge so simple, so concrete, and so inviting that pupils can hardly fail to take an interest in the problems of preserving health for the purpose of making the most of life.

The aim has been kept in view of awakening in the young a normal desire to live in such a manner as to develop strength and preserve health, because in this way one may best achieve success in securing the things which he desires, and in avoiding the disabilities and pains which otherwise are likely to occupy a considerable part of his life.

Comparatively little attention is given to anatomy, and only sufficient physiology is presented to constitute a basis for the facts of health which are discussed. Very extensive use is made of photographs and diagrams illustrating everyday life in the city and in the country. There is at least one interesting and practical original exercise suggested for every principle of health presented in each lesson. In order further to assist the teacher and the pupil, a list of questions, fully covering the text, has been given at the end of each chapter.

PREFACE

EVERY one would like to have a vigorous body, free from aches and pains and fit for any kind of work or pleasure. How can one maintain his body in this condition? This book is designed to answer this question. It shows how habits of living affect the strength, endurance, stature, symmetry, and poise of the body. Attention is given to the problem of how to keep the vital organs in good working order so that they can destroy the enemies of the body and furnish energy for all the work it has to do. A person cannot keep in good physical condition without giving consideration to what he eats and drinks, and also to the manner in which he performs these two acts; in this work these matters are considered in detail. Many people deliberately handicap themselves in the race of life, though they may not be aware of what they are really doing. This book goes into all phases of bodily care in a simple, concrete way. Topics concerning elimination of poisons from the system, helping the body to repair itself when it becomes worn, and fortifying it so that it can defend itself against attacks from without as well as from within, are given a prominent place. One cannot have the kind of body he desires, nor get the most out of life, unless the mind as governor of the body is properly trained and kept in a condition of health and poise; this subject is also treated herein.

The authors of The Everyday Health Series believe that one of the best ways to impress facts of health is to present them to the eye in photographs and drawings. This book is fully illustrated with pictures made especially for this purpose. As

an aid to teacher and pupils, each topic discussed is indicated in a marginal heading. The authors further believe that in order to get the most out of their study of hygiene, pupils should apply principles of health in their everyday life, and to facilitate this practice a list of problems relating to health is given at the end of each chapter. Lastly, a detailed list of review questions is added to each chapter. A glossary and an index are given at the close of the book.

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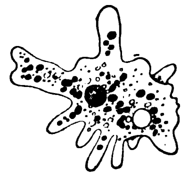
KEEPING THE BODY IN HEALTH

CHAPTER I

Living Wonders of the Body

If you look at a brick house from a distance, you can see only its general form and outline. As you come closer to it, you can see distinctly the bricks of which the house is made.

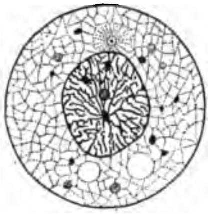
Like the house, the human body is composed of many small parts. These tiny living bricks of which the body is built are called *cells*. These cells are so small that they cannot be seen by the naked eye. When we examine a piece of flesh under a microscope, we see that it is made up of separate, distinct, perfectly formed, and exceedingly small parts. Though these differ greatly in shape, color, and use, they are all known as cells. All living things, both vegetable and animal, are composed of similar cells.



The amœba stretches itself out in the direction it wishes to go, and draws itself along like a worm.

There are some minute animals which consist of just a single cell. The *amœba*, found in ditch water and stagnant pools, is an example of a single-celled animal. Seen under the microscope, this one-celled animal looks much like a minute drop of jelly. It has no mouth, yet it can eat. It spreads itself over or around a particle of food and absorbs it, just as water flowing

down a pane of glass may pick up particles of dust. It has no limbs, yet it moves easily and rapidly from place to place. It stretches itself out in the direction it wishes to travel and draws itself along from place to place, like a worm, continually changing its form. It eats, breathes, moves, and rests. This simple and fragile little cell is so minute that it takes 850 amœbæ arranged side by side to make a row an inch long; and 100 can swim about in a drop of water which would hang on the point of a pin.



EVERY CELL HAS A NUCLEUS — WHICH MAY BE SAID TO BE ITS HEART — AND SURROUNDING MATERIAL WHICH FURNISHES IT NUTRITION. THERE ARE OTHER PARTS TO THE CELL, BUT WE DO NOT NEED TO STUDY THEM AT THIS TIME.

Whence do the tiny cells of which all living things are formed come? Every cell comes from another cell. How are cells formed? They are formed by the dividing of each cell into two new cells, as you see in the picture on page 3, and this process of division goes on until millions of cells are formed in a short time.

How the cells are formed

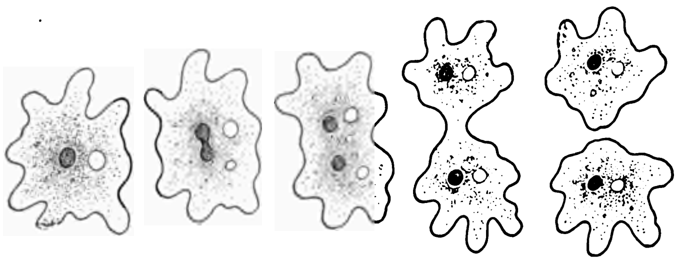
When you examine the jellylike mass of the amœba under the microscope, you see in it a dense, grayish portion, which is the *nucleus* of the cell. When the cell is preparing for division, the nucleus divides and part of it goes to each end of the cell. A wall is then formed across the middle of the cell, separating it into two parts. Each part is a complete new cell, having its own nucleus. When a single-celled animal divides in this way, each of the new cells forms a complete new animal, which grows to the size of the parent and then divides and makes two cells.

The bodies of animals larger than the amœba, instead of having a single cell, may be made up of millions of cells, each one of which is a real living being much like the amœba. Each

animal body begins with a single cell; but when this divides, the cells do not separate and live alone, as in the case of the single-celled animals. They remain together and keep on dividing and redividing until there may be many millions of them, all living together and working for the common good.

Cell colonies or communities

The body may be compared to a swarm of bees, except that in the case of the bees each one may live for some time apart from the rest if he chooses to do so. This is true to a small extent of the cells of which animals and plants are composed. When a portion is cut from a plant or animal, its cells do not always die at once. The legs of a frog will twitch and kick after they are severed from



THIS PICTURE SHOWS HOW A CELL DIVIDES TO MAKE TWO, EACH ONE A PERFECT CELL.

the body. The heart of a turtle will continue to beat for hours after its head has been removed. When some kinds of worms are cut in two, each part will live and grow into a complete worm. A flower stem cut from certain plants will continue to live and bloom for days in water. A branch cut from certain trees and stuck in the ground may even grow into a new tree. This is because each part, being made up of separate living cells, can maintain life by itself.

For this reason it is sometimes possible to remove a portion of one animal and graft it upon another animal of the same kind. In the ordinary process of grafting fruit trees, a bud of one tree

is planted in a little slit cut in the bark of another tree. When the work is well done, the bud soon becomes accustomed to its new home and grows and bears fruit and leaves like its parent.

In somewhat the same manner, surgeons sometimes take pieces of skin from one or several persons to graft upon another person who has lost, by burning or some other accident, large portions of skin. Many cases have occurred in which the severed part of a finger has been replaced and has grown on again. Surgeons often graft in portions of bone to repair diseased or injured limbs, and in a few cases even kidneys and other organs have been successfully transplanted. Organs and tissues may be kept alive for months after removal from the body, and certain tissues may even be made to continue to grow.

The human body is like a community

The human body may well be compared to a community made up of multitudes of individuals. There are few if any idlers in this community; all the cells are active workers. In most communities there are different classes of workers, such as merchants, blacksmiths, chemists, and bakers. In the body, likewise, there is a division of labor. Some cells build, others tear down. Some may be compared to artists; and others — the cells which work to keep the body clean and healthy — to scavengers. Some make different kinds of fluids to be used in the body. There are cells that stand as sentinels to give the body warning of danger, and others that are little soldiers who defend it against the enemies of life and health.

Cell structures or tissues

In the building of a house, different sets of workmen are employed for the different parts: bricklayers for laying the brick walls; carpenters for the doors and other woodwork; plumbers for the drainage pipes; and so on. In like manner, the little cell builders form themselves into groups for building up the different structures needed in the

body. These different structures are called *tissues*. A large part of the work of the cells is to build and repair these living tissues of which the body is composed.

Some of the cells form long, white, threadlike fibers, which are very tough and unyielding. This fibrous tissue is needed to bind the different parts of the body together and to make cords and protective coverings. There is also a yellow elastic tissue which may be stretched like India rubber.

The yellow elastic tissue and the fibrous tissue together form, in all parts of the body, a marvelously strong though elastic

THIS WHITE CORD-LIKE TISSUE BINDS THE DIFFERENT PARTS OF THE BODY TOGETHER.

THIS YELLOW ELASTIC TISSUE ALSO BINDS THE TISSUES TOGETHER AND SERVES FOR BANDS, COVERING MEMBRANES, AND SHEATHS.

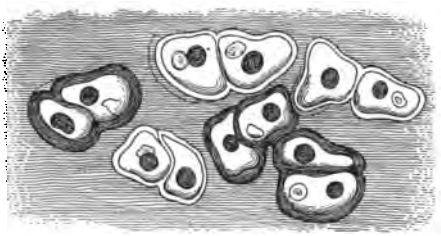
ADIPOSE TISSUE, FORMED BY CELLS OF FAT OCCUPYING THE MESHES OF THE CONNECTIVE TISSUE, MAKES CUSHIONS FOR DELICATE ORGANS LIKE THE EYE.

mesh-work called *connective tissue*. This binds the tissues together, forms sheaths, membranes, bands, pouches, and coverings, and serves everywhere for purposes of protection and support.

The meshes of the connective tissue network in some parts of the body are occupied by cells composed of fat. This soft

adipose tissue, as it is called, rounds out the form, makes cushions for delicate organs like the eye, and serves other useful purposes.

Other groups of cells form what is called *muscular tissue*, and by this all sorts of movements are made. This tissue is composed of minute fibers which shorten and lengthen, much as an earthworm contracts and extends its body when in motion.

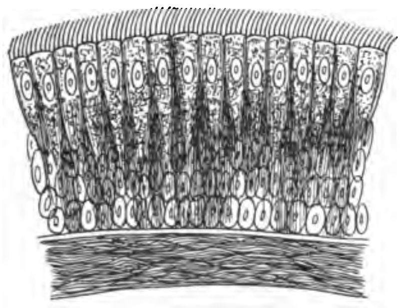


THESE CELLS ARE FOUND IN CARTILAGE TISSUE. REMEMBER, ALL TISSUES ARE COMPOSED OF CELLS.

The hardest of the tissues which the cells build up in the body is called *bone* or *osseous tissue*. The bones serve as supports for the body and as levers by means of which it is moved about by the muscles.

Cartilage tissue, which is usually connected with the bones, is something like the bone tissue, but softer and capable of bending under pressure.

The most remarkable groups of cells found in living beings are in the *nervous tissue*, of which the brain and nerves are composed. These are used in thinking and feeling.



LAYERS OF CELLS LIKE THESE COVER THE ENTIRE SURFACE OF THE BODY AND LINE ALL CAVITIES. THEY ARE EPITHELIAL CELLS.

Layers of curious cells cover the whole surface of the body and line all its cavities. These are called *epithelial cells*, because the skin or covering that they help to form is called *epithelium*.

Among the most interesting of the many millions of cells in the body are the *gland cells*. The glands are groups of cells which form peculiar substances for the carrying on of the work of the body. There are many different kinds of gland cells. Some sets of these cells form *saliva;* others make *gastric juice;* others are found in the liver, making *bile*. Millions of little groups of cells found in the skin make *sweat;* others make *fat* which oils the hair and the skin. Other gland cells separate from the blood poisonous substances which are formed in the body or which are taken in with the food or drink.

Gland cells

GLAND CELLS

A, after rest; *B*, after slight activity; *C*, after greater activity

In studying all these cells and their work, one is constantly led to marvel at their alertness, faithfulness, industry, and perseverance.

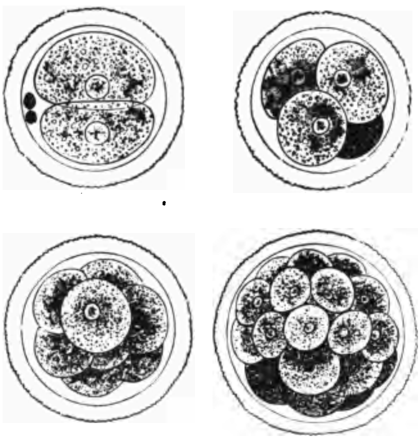
The one-celled animal, living alone, must do everything for itself. All that is necessary for its life must be performed by that single cell. It moves itself about, gathers its own food, eats and digests it, and discharges its wastes. In the community of cells that form the living body, however, the work is divided, — different duties being assigned to different groups of cells. The cells doing the same kind of special work for the body are grouped together, and these cell groups are called *organs*.

Cell groups are called organs

All many-celled animals and plants have the work divided

among the different organs, and so are said to be organized and are sometimes spoken of as *organisms*. They are said to belong to the *organic world*. A rock or a mountain, which has no organs, is said to belong to the *inorganic world*.

As the wood, brick, stone, and mortar are combined and arranged to form the parts of a house and its furniture, so the simple structures or tissues are combined and arranged to form the different organs of the body. In the hand, for example, we have bone, muscular, connective, and skin tissue combined in such a way as to form an organ suitable for grasping. Some organs, like the heart, are made chiefly of one kind of tissue.



THE CELLS WHEN THEY DIVIDE UNITE TO FORM COLONIES OR ORGANS.

Each organ has its special work to do for the body, and the life and health of all the cells depend upon its doing its work well. The stomach and intestines are organs for digesting the food; if they fail in this work all the body cells starve. The lungs take in the oxygen that the cells need, and the kidneys remove poisonous and waste matters. The heart pumps the blood which carries the food supply to every part of the body, furnishing all the cells with nourishment. The brain and spinal cord send out tiny living threads, called *nerves*, which run throughout the body, dividing and subdividing until they reach every part of it and bring under their influence each individual cell, with the exception of the floating cells in the blood.

When all the cells and organs of the body are acting properly, a person is said to be in a state of health. When anything interferes with the work of any of the organs, so that it is done imperfectly or not at all, the person suffers discomfort and is said to be in a state of ill health or *disease*. It is of the utmost importance that the vast army of little workers of which we are formed should be kept in health and vigor. Anything which injures them or hinders their activity is dangerous to our life and health.

Cells and organs in health

There are some things which have a very injurious effect upon organs of the body. Among these are tobacco and alcohol. By numerous experiments upon animals, and by examinations made after death upon the bodies of persons who had been addicted to the use of alcoholic drinks, it has been found that every tissue of the body, especially of the liver and the brain, is injured by alcohol. Alcohol lessens the activity of the cells that build the body and, taken in strong doses, may even paralyze them completely. This is one reason why a person who indulges in alcoholic drinks does not recover from an accident so quickly as one who does not use alcohol. The cells are hindered in their work of repairing the damage that has been done. Many eminent surgeons have noticed this fact.

Tobacco has almost as bad an effect as alcohol upon the tissue-building cells. This is the reason why the boy who begins to smoke at an early age is usually stunted in his growth and puny.

Health Problems

1. Suppose you were talking with a person who thought that stones were made up of cells. What should you say to him to make it clear that cells are found only in living things?

2. Mention several communities or colonies of cells in the human body. What are these communities or colonies called?

3. Have you ever seen a tree grafted? How was the work done? Did the graft live? If so, explain how this was possible.

4. What is meant by saying that the body is a community? Show in what way it resembles, in number and in kinds of workers, a community like the one in which you live.

5. Tell where in your body white fibrous tissue can be found; connective tissue; adipose tissue; osseous tissue; cartilage tissue; muscular tissue; nervous tissue.

6. Suppose some one organ of the body did not do its duty. Would this affect the body as a whole? Is the effect the same in the community in which you live, when some person does not do his duty?

Review Questions

1. Why can we not see the cells of the human body with the naked eye?

2. If you should examine a piece of flesh under a microscope, what would you see?

3. Describe the amœba as seen under a microscope.

4. How are the cells of the body formed?

5. Of what are the bodies of large animals composed? With what does the body of every animal begin?

6. What is meant by saying that there is "division of labor" in the human body?

7. How are the tissues of the body made?

8. Mention the various kinds of tissues and their uses.

9. What are the epithelial cells? Where are they found?

10. What are the gland cells and what are their uses?

11. What is the meaning of *organs*? Mention a number of organs in the human body.

12. What has been found regarding the influence of alcohol upon the workers of the body? What organs are hurt most by alcohol?

13. What is the effect of tobacco upon the workers of the body?

CHAPTER II

The Maintenance of the Body

No large community of people remains exactly the same for any length of time. Constant changes take place in it. Daily, some of its members die while new ones are born; some move in and others move away. When the number added is greater than the number lost, the community grows in size. Do you know that this is true also of the communities or colonies of cells that compose the living body? Many millions of the cells die in the course of a single day. Seven million blood cells die every second of our lives. If no new ones were supplied to take their places, what would happen to the body? Besides the cells needed to take the place of those that have died, the child or the young animal needs an increase of cells to provide for its growth. Why?

How we grow

All living things grow. This is one of the chief differences between organic and inorganic objects. A lifeless object, such as a rock or mountain, does not grow, although it may increase in size by the simple addition of material. Living things, plants and animals, grow by taking material into themselves and changing it into their own substance. The growth of a human being, from the very beginning until he reaches full stature, can take place only through the making of tissues from the food he eats.

All the cells of the body that are living and active, need food to maintain their life and to supply them with energy for

their work, and to furnish fuel to keep them warm. *Hunger* is the appeal of the body for more fuel and building material.

The living body is like both a house and a machine. A machine wears out much more quickly than a building, for the reason that it works. The work performed in and by the body wears it out, so that it is in constant need of repairs. The wearing out process is so great that the entire body is rebuilt many times during a long life. How is the material for the necessary repairs supplied?

The living human body is always warm. In summer or winter, no matter what the temperature of the surrounding air may be, the body temperature is always maintained at nearly 100 degrees. In *Building Health Habits* you have learned about the *combustion*, or slow burning, by which the body heat is kept up. To produce heat something must be consumed. The life fire that warms the body consumes its cells just as burning consumes a candle or as fuel is consumed in a stove. Of course, a constant supply of fuel is needed to keep this life fire steadily burning.

What is ordinarily spoken of as *fire* is an active burning, accompanied by a flame. When combustion is less active the heat is less intense, and there may be no visible flame. It is by this latter kind of combustion that a dead tree, lying upon the ground in the woods, is gradually consumed. In time it will disappear as completely as if it had been burned up in a stove. The amount of heat produced by the burning of a tree is just the same, whether it rots in the forest or is burned in a furnace; but in the furnace the heat is given off in a much shorter time.

Another important source of bodily waste is work. The locomotive cannot pull its train of cars without using coal. The amount of fuel consumed by a locomotive is in proportion to

the amount of work it does. So the locomotive which pulls the largest train consumes the most coal. Just as the locomotive gets its power to work from the fuel that is burned under its boiler, so the body gets its power to work from the food that is eaten. All the work done in and by the body consumes materials that must be replenished by the food supply. The body, therefore, has as *its source of energy,* — *food.* The greater the amount of work done, the greater the amount of food needed. Think for a moment of the tremendous amount of work performed daily by the cells of the body. It has been carefully estimated that the work which the body is capable of doing daily is equal to the lifting of 900 tons to a height of one foot. More than one tenth of this work is done by the heart, which is constantly at work, apparently without rest day or night, pumping the blood to every part of the body. The work of the lungs, and of the muscles that move the breathing apparatus, also goes on every moment during life. The balance of the work is done by the digestive organs, the glands, the brain, the nerves, and the muscles.

How the cells get their energy

We see then that there are two things that the food supplies to the body: *material* for the building of body tissue, — bone, muscle, blood, brain, and all the organs of the body; and *energy,* which is used in the body in many different ways, — producing heat, doing muscular and mental work, keeping the heart beating, and enabling all the different organs and glands of the body to perform their work.

By chemical examination, the body has been found to be made up of many different substances, chief of which are oxygen, hydrogen, carbon, nitrogen, and lime. As you look carefully over the following table, note the amount of each one of the different substances named contained in the body of a person

weighing 150 pounds, and remember that each one is absolutely essential, although the amount needed may be very small.

Oxygen	97.5 Pounds
Carbon	27.0 Pounds
Hydrogen	15.0 Pounds
Nitrogen	4.5 Pounds
Calcium	3.0 Pounds
Phosphorus	1.5 Pounds
Potassium	.5 Pound
Sulphur	.4 Pound
Chlorine	.2 Pound
Sodium	.2 Pound
Magnesium	1.2 Ounces
Iron	.1 Ounce
Fluorine	Traces
Silicon	Traces

Let us now see where we get the material that forms our bodies. Every particle of it comes from the earth, the air, and the water. The human body, however, does not have the power to make living cells out of earth and air. Here, for instance, are a piece of bread and a piece of coal. Both contain material and energy, and some of the same elements. Yet one is a food. and the other is not a food. The coal may be burned in a locomotive to furnish both heat and energy, but cannot be used in the human body.

The sources of the material in the body

The plant is the workshop or factory where the food for animals is produced. The material coming from the earth, the air, and the water must first become a part of the plant before it can be used by animals as food. A plant, for example, takes carbonic acid gas from the air. This is not a food. From the soil the plant takes up water, combines it with the carbonic acid gas, and makes starch, which is a food.

The plant makes food in its leaves, which serve as its stomach

and lungs. The green color of leaves is due to the presence of little grains of *chlorophyll* (klō′rŏ-fĭl). Each of these little grains is a wonderful laboratory where food for the plant is made out of carbonic acid gas and water. The carbonic acid gas is taken from the air, while the water comes to the leaves through the roots.

Sunlight, the great source of energy, cannot be absorbed directly by the body. The chlorophyll grains capture the sunlight and store the energy which it brings. Every vegetable product, as wheat, corn, and potato, is such a storehouse. Every fruit, every seed, every nut, is a little bundle of concentrated light, stored until it is needed for the growth and development of a new plant or to furnish heat and energy to some member of the animal kingdom.

Plants the only food producers

This calls our attention to an important difference between plants and animals. A plant is a food *producer*, a *storehouse* of energy. An animal is a *food consumer*, an *expender* of energy. Animals, although they are sometimes used for food, do not *make* foods. A plant is the only real food factory. A lion, in dining upon an antelope, is only eating at secondhand the grass and herbs which the antelope has eaten. A man, in eating roast beef, is taking at secondhand the corn upon which the ox was fed.

Composition of foods

We must now study the substances that are adapted to serve as food for man. A substance which can be used by the body to furnish it with material for building or repairs or with energy for heat and work is called a *nutrient*. We have seen that one purpose of food is to supply the body with warmth and with power to work. These special needs are met by two classes of nutrients, *carbohydrates* (starch, dextrin, and sugar) and *fats*. The building material for the body is furnished by a third class of nutrients called *proteins*. These

— carbohydrates, fats, and proteins — are the three great classes of nutrients.

In addition there are —

Salts, which are essential not only for the bones, but for all living tissues of the body. (By salts we do not mean "table salt," but organic combinations of lime, magnesia, phosphorus, potash, iron, and other elements.)

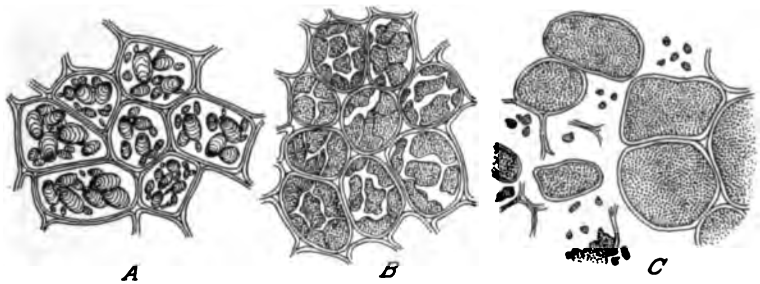
Flavoring Substances, which render the food agreeable to the taste.

Cellulose, an indigestible substance found in all vegetable foods, which is highly essential to give bulk to the food mass, to stimulate the activity of the stomach and intestines, and to enable the colon to dispose of body refuse.

Vitamines, subtle substances which are found in fresh, uncooked foods, and which are absolutely necessary for the complete nourishment of the body. These substances are so refined and so active that little is known about them except the fact that they exist and that some of them are likely to be destroyed by cooking. Sailors get scurvy by the exclusive use of cooked food.

Starch is the most abundant of the food elements. It is found in all grains and vegetables, and in green fruits, though not in ripe fruits. Starch consists of little granules, each one of which is inclosed in an envelope of cellulose, which is the substance from which paper is made. The process of cooking breaks open the envelope and releases the starch, which can then be reached and acted upon by the digestive fluids in the body. The accompanying picture shows different kinds of starch granules. The starch particles of the potato are much larger than those of grains and are much more easily digested. The picture shows the change that occurs in starch granules as a result of cooking.

Sugar, although very unlike starch in appearance and taste, is almost like it in composition. When starch is digested it is made into sugar. Sugar is found in all fruits and in some vegetables, such as corn, beets, and sweet potatoes. There are different kinds of sugars. The sugar of fruits is called fruit sugar. A sweet substance found in milk is known as milk sugar.



THIS PICTURE SHOWS THE CHANGE THAT IS MADE IN STARCH CELLS OF POTATOES BY COOKING. *A*, cells of raw potato; *B*, cells of partially cooked potato; *C*, cells of boiled potato

A peculiar sugar produced in the sprouting or malting of grain is called malt sugar or maltose. Sugar furnished by the sugar cane, the beet root, or the sap of the maple tree is known as cane sugar.

Fats are found in both animal and vegetable foods. Butter, lard, and suet are the principal forms of animal fats used as foods. Vegetable oils come chiefly from nuts, from various seeds such as the cotton seed, from the soy bean, and from oily fruits such as the olive.

Proteins contain the carbon, hydrogen, and oxygen found in fats, starch, and sugar. In addition to these they also contain nitrogen, and because of this they are sometimes called nitrogenous foods. Proteins are abundant in animal foods, — lean meat, milk, cheese, and eggs. Of the foods obtained from plants, proteins are found chiefly in nuts, peas, beans, and lentils,

though they are contained also in all grains and in very small quantities in most vegetables. Phosphorus and sulphur are also found in proteins. The iron, lime, and salts of food are mostly found with the proteins.

List of Common Foods Rich in Proteins, Fats, and Carbohydrates

Proteins	Fats	Carbohydrates
(*Animal*)	(*Animal*)	(*Animal*)
Milk	Milk	Milk sugar in milk
Cheese	Cream	Honey
	Cheese	
Eggs	Butter	
Meat	Egg yolk	
	Suet	
	Lard	
	Fat meat	
(*Vegetable*)	(*Vegetable*)	(*Vegetable*)
Legumes (dried peas, beans, especially the soy bean, lentils)	Nuts	All cereals; all foods made from cereals; starchy vegetables, particularly the Irish potato, the sweet potato, green corn, green peas; legumes; sweet fruits, fig, banana, apple, prune, pear, raisin, date; sugars; chestnuts, and some other nuts
Nuts	Coconut oil	
Oatmeal	Olive oil	
Wheat	Other vegetable oils	
	Oleomargarine	

Uses of the different foods

The carbohydrates and fats, which are composed of the same elements (carbon, hydrogen, oxygen), serve the same purpose in the body. They are the fuel or energy-giving foods, which are burned up in the body to furnish it with warmth and with power to work. When not needed for immediate use, they may be stored up in the tissues

of the body, just as coal is stored up in the tender of a locomotive to be used as needed.

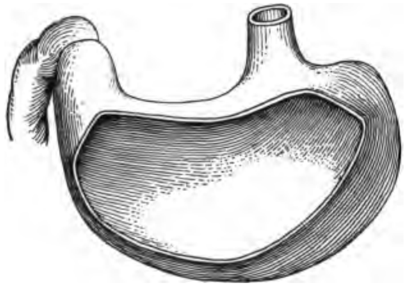
The proteins are a most important class of nutrients because they furnish the building material for the body. Just as the carbohydrates and fats correspond to the coal burned in the locomotive, the proteins correspond to the iron, brass, and other materials out of which the locomotive is made. Nitrogen, which is contained only in proteins, is an element needed for cell building, and it is this that gives the protein foods their great importance. A growing child, whose body is in process of building, needs these nitrogenous foods in larger quantities than a person who is full-grown and needs only the material necessary for repairs. The foods which nature has provided for the use of young animals are rich in proteins. The white or albumen of the egg, out of which the young chick is to be formed, is composed wholly of this element. Milk, which is the natural food for young animals, also contains an abundance of protein.

Proteins may be burned in the body to furnish energy, but their chief use is for building. There is no provision in the body for the storing up of the proteins, or building foods, as there is for the storage of the fuel foods, hence it is important to take just the proper amount each day, avoiding excess.

Certain *minerals* are needed in small amounts. Of these common salt is the one most familiar to us. This is found in sufficient quantities in most of our foods, but we often add more in cooking and eating,—sometimes too much. Lime, which is especially needed by a growing child for the building up of his bones, is found chiefly in milk, grains, and eggs. A small but very necessary amount of iron is needed for the formation of the red blood cells. This is found especially in the yolk of egg and in the green parts of vegetables.

Another substance very necessary to the body is water, which

as you know comprises a large part of the body. Water is lost from the body chiefly in the removal of wastes. It is also constantly passing off through the lungs and skin in the form of an invisible vapor. The moisture of the breath can be seen when one is in the open air on a frosty morning. When one exercises violently, or is exposed to great heat, the water thrown off by the skin becomes visible in the form of perspiration.



YOU CAN SEE FROM THESE PICTURES WHAT HARM ALCOHOL DOES TO SUCH DELICATE ORGANS AS THE STOMACH. THE UPPER PICTURE SHOWS A HEALTHY STOMACH AND THE LOWER ONE THE INFLAMED STOMACH OF A DRUNKARD.

The amount lost daily is three or four pints, and this loss must be made good by drinking water or getting it in food. We get a considerable amount in our foods. Even what are called dry foods, such as rice and beans, contain some water, and other foods are largely composed of it. Potatoes, for instance, are more than eighty per cent water.

Another substance that is absolutely necessary to the life and work of the cells is oxygen, which we get from the air. If the supply of oxygen is cut off from the body for only a few moments, the life fire dies out. How the necessary oxygen is supplied to the cells and what use is made of it will be told in another chapter.

A poison is just the opposite of a food. Instead of furnishing

the body with nourishment, it interferes with the life and work of the cells, disturbing them in such a way as to cause sickness and death. A true food must not contain any substance that is in any way harmful to the body.

Poisons, the opposite of food

In recent years there has been much discussion as to whether or not alcohol is a food. Alcohol, as we have already learned, paralyzes the cells that make bone and flesh. All the delicate organs by which the life work of the body is carried on are injured by it and hindered in their work. Not only are the organs injured and weakened by it, but the task of removing this injurious substance from the body adds greatly to their work.

No food prepared for us by Nature is composed solely of one of the nutrients that we have been studying. They are combined in the foods in the way in which they will best meet the needs of the body. We might dine with a king and have a very elaborate menu with the food prepared in many different ways, but the food cannot have in it more than these few simple nutrients that we have studied.

Health Problems

1. Have you noticed how very hungry growing puppies and kittens are all the time? Explain. Is this true of all growing animals? Why?

2. Suppose one could not eat any food, what would happen to him? Why? Would it happen more quickly if he had to work hard than if he were idle? Why?

3. Have you ever had a physician "take your temperature"? If so, why did he do it?

4. When one goes out into zero weather, how is the warmth of the body kept up to about 99 degrees? What would happen if the bodily temperature should drop a few degrees?

5. Think of some way to prove that the cells feed on the food taken into the body.

6. Are you more hungry when you work or play hard, or are out in

the cold much, than when you stay in a warm house and do no work? Explain.

7. Can you tell starchy foods, fats, foods rich in sugar, and those rich in protein by the sense of taste alone? Explain.

8. Should a growing boy eat more eggs, peas, beans, cheese, and such foods than a full-grown man who is doing very little muscular work? Why?

9. Show by an experiment that a potato, or an apple, or a cucumber is largely water.

Review Questions

1. What is necessary that a living thing, whether plant or animal, may grow?

2. What do living cells need in order to maintain their life?

3. Why is the living body like both a house and a machine?

4. What is the normal temperature of the body?

5. How is heat produced in the body?

6. What is the difference between the burning of fuel in the human body and the burning of fuel in a stove?

7. How do the cells get the energy for their work?

8. What happens in the body when work is done? Show that the body at work is something like a locomotive pulling cars.

9. What organs of the body are constantly at work?

10. What two things does food supply to the body?

11. What must happen to the material coming from the earth, the air, and the water before it can be used by animals as food?

12. How does a plant make starch for our use?

13. Which nutrient supplies the building material for the body? Which supplies the warmth and power? Which the material for making bones and teeth?

14. Where is starch found abundantly? Discuss starch as a food.

15. In what fruits and vegetables is sugar found? Name the kinds.

16. In what foods are the fats found? The proteins?

17. Which of the classes of nutrients does the growing animal need especially?

18. Mention the minerals which are needed in the body. In what foods are they found?

19. How does a poison affect the body? Is alcohol a food or is it a poison?

CHAPTER III

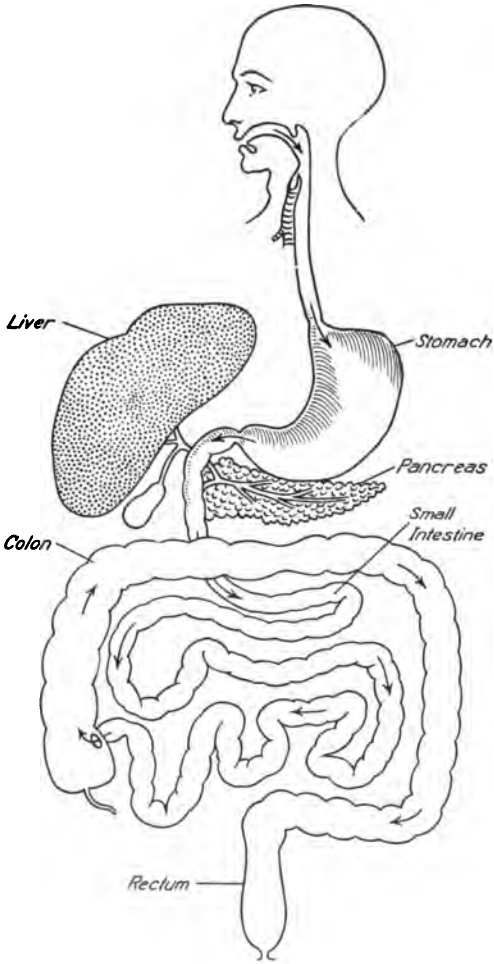
How Food Becomes Living Tissue

The food substances or nutrients about which you have been learning cannot be taken up just as they are and used by the cells as food. A great deal of preparatory work is necessary. This work of preparation is called *digestion*. We have already seen how the work of the body is divided among the different groups of cells that form the organs of the body. The groups whose work it is to prepare the food are called the *digestive organs*.

If you have visited a large bakery establishment, you have seen how the work is divided among the different workers. One worker attends solely to the mixing and kneading of the dough, which is then passed to another who spends his time in rolling it out to the required thickness. Another worker then takes it and cuts it into pieces of the right size and shape and passes it to yet another who superintends the baking. In like manner the food you eat is passed from one to another of the cell groups, called the digestive organs, and each group has some special part of the work of preparation, or digestion, to perform.

The food canal

The long, narrow tube in which the work of digestion takes place is called the *alimentary canal* or food tube. *Aliment* means food, and the alimentary canal is simply the food channel of the body. It is from twenty-five to thirty feet long and is lined throughout with a fine pink lining called *mucous membrane*, which you can see in the mouth. This



THE DIGESTIVE ORGANS

is always kept moist, so that the food may easily be moved along the tube.

The cell groups whose work it is to prepare the food are stationed at various places along the route that the food must travel, just where their services are needed. Each group prepares a special kind of fluid or juice which it pours out upon the food. These fluids are called the *digestive juices*. There are five digestive organs, and so there are five different digestive juices.

All the food must be soaked up or absorbed by the walls of the canal in order to pass through it into the body for the use of the cells, which can take their food only in a liquid form. Most of our foods consist of solid particles which do not dissolve in water. Put some sugar in a glass of water, and you will find that after

a few minutes the sugar seemingly completely disappears. It is dissolved in the water, and you can detect its presence only by the taste. If you treat a piece of bread in the same way, you will see that it does not dissolve in the water but only mixes with it. If you strain through a fine sieve or cloth the water containing the sugar, both sugar and water will pass through together and there will be nothing left on the cloth. But if you strain in the same way the water with which the bread has been mixed, the water will pass through the cloth and most of the bread will remain behind.

Digestive juices

The work of digestion is simply the work of changing the insoluble (look up the meaning of *insoluble*) food substances into substances that will readily dissolve and so pass easily through the walls of the food tube into the blood.

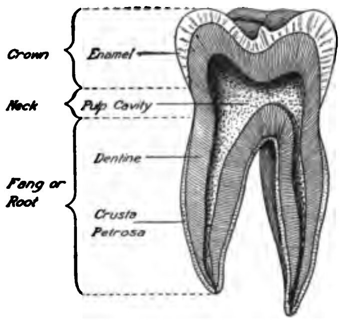
At the very entrance of the food canal is a station where the food must tarry for a while and be worked over before it starts on its journey through the body. This station is the mouth, the first of the digestive organs. The work done in the mouth, as we learned in *Building Health Habits*, is of the utmost importance, because all the rest of the work of digestion depends upon thorough preparation of the food in the mouth.

The first step in digestion

An important part of this work is the chewing or mastication of the food, which is done by the teeth. An infant is born without teeth. Between the ages of seven months and two years the temporary or milk teeth, twenty in number, make their appearance. By the twelfth year these temporary teeth have given place to the permanent set. A complete set of permanent teeth in an adult consists of thirty-two teeth. Each jaw contains four front teeth, called incisors or cutting teeth; two cuspids, one on each side of the incisors; four bicuspids, two on

each side; and six double teeth, three on each side, called the molars or grinding teeth.

The teeth are helped in the work of mastication by the tongue, which moves the food about, passing it from side to side of the mouth until it is all thoroughly chewed. In the tongue also are *taste buds* by which the different flavors in foods are detected.



A SECTION OF A TOOTH. WHAT IS THE USE OF THE ENAMEL? OF THE DENTINE? WHAT IS THE TROUBLE WHEN A TOOTH ACHES?

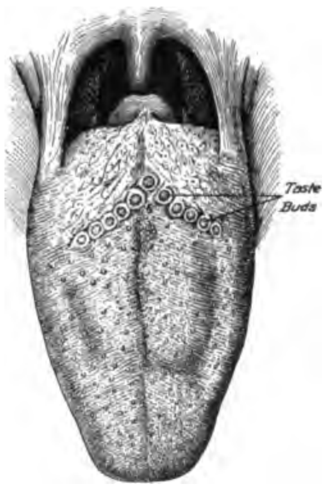
The work of the saliva

The work of mastication is also assisted by the *saliva*, the first of the digestive juices to be poured out upon the food. This moistens and softens the food, so that it is more easily made into a creamy pulp.

The saliva does much more to the food than merely to moisten it. If you chew a hard crust of bread thoroughly, you will notice that after a while it becomes quite sweet to the taste. This is because some of the starch in it has actually been changed by the saliva into the kind of sugar called *maltose*.

The groups of cells which prepare the saliva and pour it on the food are called *salivary glands*. When we are eating we should be careful not to discourage these glands from working by drinking large quantities of liquid. Dry food does not need to be "washed down," though many people seem to think so. Saliva is formed and poured out each moment in quantities exactly suited to the nature and quality of the food that is being chewed. If the food is already moist, the quantity of saliva produced will be very small. Why? When liquid foods like milk are taken, little or no saliva will be produced. Dry and highly flavored foods cause the salivary glands to pour out an

abundance of saliva. Why? Food containing starch, which needs an abundant outflow of saliva, should of course be eaten *dry* and *should be thoroughly chewed.* It is very necessary that the food should remain in the mouth long enough for a sufficient amount of saliva to be poured out upon it, and that it should be so thoroughly chewed that the saliva will become mingled with every part of it.



THIS PICTURE OF THE UPPER SURFACE OF THE TONGUE SHOWS THE TASTE BUDS ESPECIALLY. CAN YOU TASTE ANYTHING WITH THE VERY TIP OF THE TONGUE?

The process of starch digestion is not confined to animals alone. Most plants are capable of transforming starch into sugar. This change always takes place in the ripening of fruits. The starch of the green apple, for example, is changed into the sweet, wholesome sugar that flavors the ripe fruit. By a similar process, the starch stored up in the fall by the roots of the maple tree is in the spring converted into sugar and carried up in the sap. It is in this way also that the honey of plants is formed and deposited in the flower cups from which it is collected by the bee.

When the food has been sufficiently acted upon in the mouth, it passes on its way through the alimentary canal. The muscles at the back of the mouth seize the food and carry it into the *gullet* or *esophagus,* — the name given to that part of the food canal that connects the mouth with the stomach.

The muscles at the back of the mouth seem to act as gatekeepers to guard the entrance to the esophagus. At frequent

intervals during mastication they move the food forward in the mouth, keeping it there until it has been thoroughly chewed, after which they are ready to let it pass on. The food then seems to "swallow itself," without any effort on our part. People very often *force* the food from the mouth back into the esophagus before it has had the proper mouth treatment. If the act of swallowing requires a conscious effort, we may be sure that the food has not been in the mouth long enough.

The path to the stomach

The esophagus is not a tube through which the food is simply dropped into the stomach. The walls of the entire alimentary canal are composed, in part, of muscles, arranged in such a way as will best assist the work of the different digestive organs. By means of the muscles in the esophagus, the food is moved along until it reaches the second food station, — the stomach.

To form the stomach, the food tube is widened into a broad pouch, as shown in the picture on page 24. At each end of the pouch is a strong circular muscle which guards the entrance and the exit. The entrance is called the *cardiac opening*, and the exit is called the *pylorus*, meaning the "gatekeeper." The large end of the stomach near the cardiac opening, where digestion chiefly takes place, is called the cardiac end; the lower and narrower end, which is chiefly composed of very strong muscles, is the pyloric end.

Even before the food reaches the stomach, a very important work of preparation has been going on there. Nature has installed in the body, to help on the work of digestion, a kind of signaling system by means of which the digestive organs are given notice when food is to be expected. The cell workers then at once begin active preparations for their work.

Stomach digestion

You have noticed how, at the mere sight or odor of appetizing food — when you smell a good dinner cooking, for example —

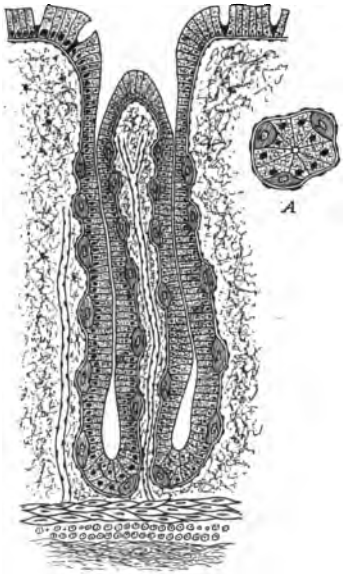
the mouth begins to "water." This is because a sort of telegraphic message has been sent from the brain to the salivary glands, and they have immediately begun to pour out a quantity of saliva in readiness for the food that is expected. Something of the same kind takes place also in the stomach. A Russian scientist, Professor Pavlov, made many experiments upon dogs and men by means of which he discovered some very interesting facts about the work of digestion, especially that part of the work that is done in the stomach. He made a device by which he could actually see into the stomach of a dog and find out exactly what took place there. When the dog was hungry, the mere sight or smell of food caused the stomach, as well as the mouth, to secrete its digestive juice, and it continued to do this all the time the food was being chewed. By the time the food actually reached the stomach, there was a quantity of digestive juice ready for it.

The digestive fluid that is poured upon the food while it is in the stomach is called *gastric juice.* It makes its first appearance upon the walls of the stomach in little drops, like tiny beads of sweat upon the skin. As the quantity increases, the drops run together and trickle down the sides of the stomach in little streams. The membrane lining the stomach, when seen under a microscope, is found to have many minute openings. Each of these openings is connected with a narrow tube which extends into the walls of the stomach, making a kind of pocket. This little pocket is lined with living cells, which during the process of digestion are actively at work making the gastric juice.

The gastric juice

The gastric juice has no action upon starch, sugar, or fats, and only digests some of the protein of the food. There are two digestive substances made by the gastric glands. These are pepsin and rennin, and are called *ferments.* The principal work done in the stomach is to liquefy the food.

The rennin in the gastric juice has an interesting work to perform in connection with the digestion of milk. If milk were to remain in the liquid form in which it is swallowed, it would pass quickly out of the stomach without digestion. The rennin changes the milk into curds, so that the proteins which it contains can then be acted upon by the pepsin. If the curds are hard and tough, the work will be harder and the milk will not be so well digested. For this reason it is not a good thing to swallow milk rapidly, in large quantities, as one does water. A nursing babe takes the milk in small quantities. The natural method of drinking milk is to take it in small sips, so that it can form small curds, which can easily be acted upon by the gastric juice.



THE JUICE THAT IS POURED OUT ON THE FOOD IN THE STOMACH IS MADE IN GASTRIC GLANDS, LIKE THE ONE SHOWN IN THE PICTURE; THESE ARE FOUND IN THE LINING OF THE STOMACH.

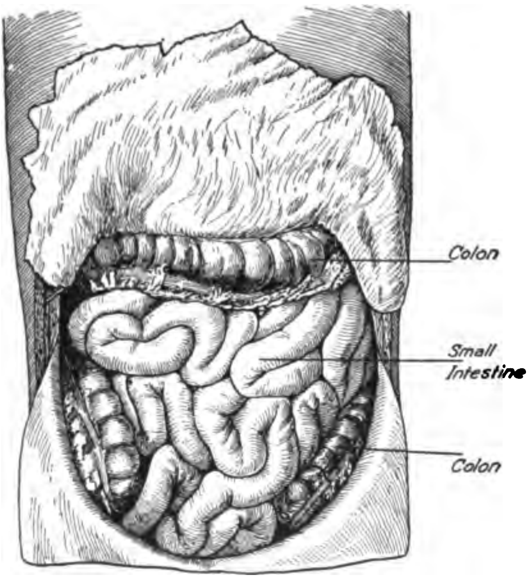
The flow of the gastric juice is, like that of the saliva, regulated in a most exact manner, both in quantity and quality, to suit the foods that are eaten. Foods containing a large amount of protein call forth an abundant flow of gastric juice, whereas starchy and fatty substances, which are not digested in the stomach, do not excite the gastric glands to lively activity.

The pepsin alone cannot digest protein, since it requires an acid to make it active. Some of the gastric glands pour out a strong acid called *hydrochloric acid.* When the food becomes

thoroughly mixed with the gastric juice, as is the case about an hour after it enters the stomach, the digestion of the starch, which has been going on up to that time, ceases. The acid in the gastric juice also does the important work of destroying bacteria or germs that get into the stomach through the mouth. So the stomach is a kind of disinfecting room for protecting the body against germs.

Kneading the food

Next to the lining membrane, which contains the gastric glands, is a coat of muscular tissue. By contracting these muscles, the stomach is able to change its size and shape and to produce a sort of *kneading* action upon the food, thus softening it and thoroughly mingling it with the gastric juice. This work is kept up until the whole mass is soft and is something like a thick soup.



THE SMALL INTESTINE IS A VERY ACTIVE LABORATORY FOR DIGESTION. THE COLON, OF WHICH YOU CAN GET A GLIMPSE IN THE PICTURE, IS A RECEPTACLE FOR WASTE AND FOR PORTIONS OF FOOD THAT CANNOT BE USED.

The food begins passing from the stomach within a few minutes after eating begins. At brief intervals the pylorus opens and passes out a small amount of the digested liquid food; and at the end of four or five hours the stomach is completely emptied.

When the food passes through the pylorus, it enters the next and most important of the digestive organs, the small intestine, which is the third food station. This small intestine is a slender tube, about twenty feet long, that passes from the stomach to the large intestine or colon. You can see in the illustration on page 31 the curious way in which this long tube is coiled and packed in the part of the body it occupies. The contact of the acid liquid with the mucous lining of the intestine causes the pylorus to close. The pylorus remains closed until the acid liquid from the stomach is neutralized by the alkaline bile and pancreatic juice.

We have already studied the work of two of the five digestive fluids. The three remaining juices are poured upon the food while it is in the small intestine.

Digestion in the small intestine

One of these is poured out by the intestine itself and is called *intestinal juice*. The other two are secreted by two large organs lying near the stomach, the liver and the pancreas.

The fluid prepared by the liver is called *bile* and is stored up in a sack or pouch called the *gall bladder*. When needed for the work of digestion, the bile is poured through a duct into the small intestine, in much the same way that the saliva is poured out into the mouth. The duct enters the intestine a few inches below the stomach.

Up to this point in the work of digestion, the starch has been acted upon by the saliva, and the proteins by the gastric juice; but no change has taken place in the fats, except that they have been melted by the heat of the body. The special work of the bile is to aid in the digestion of the fats. Fats are first emulsified, or subdivided into particles so small that they may be absorbed. An emulsion may be made experimentally by mixing olive oil with a quantity of gum water. Add three or four

parts of water to one part of mucilage, shake until well mixed, and then add one part of oil. Note that when the oil is first added the two liquids remain distinct. Shake the mixture thoroughly for a minute; it will then be impossible to distinguish the oil from the gum water. The result will be a creamy liquid, which, added to water, produces a mixture having a milky appearance. If allowed to stand for a while, the emulsion will rise to the top as cream rises upon milk.

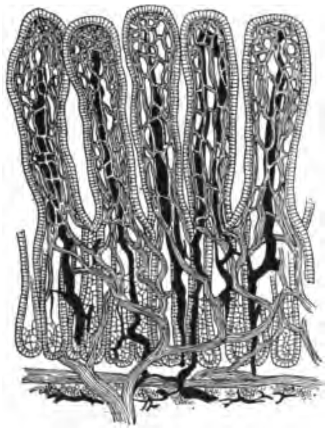
Next the fats are changed into soaps by combining with the alkaline substances of the bile and *pancreatic juice.* In the form of soaps, the fats are soluble and can be absorbed. After absorption, the soaps are changed back into fats.

The pancreatic juice is formed by a gland called the *pancreas* which is located near the opening of the small intestine. The remarkable thing about the pancreatic juice is that it does the work of all the other juices combined. It digests starch, like the saliva; it digests proteins, like the gastric juice; and it acts upon fats, as does the bile. Why should there be this arrangement in the food canal, do you think?

The powerful pancreatic juice is poured out near the entrance to the small intestine, so that the digestive work to be done there is well started. The intestinal juice, which is poured out along the whole twenty feet of the intestine and does much the same kind of work as the pancreatic juice, completes the work started by the pancreatic juice. In addition to this, the intestinal juice has the power of digesting cane sugar, which is the only kind of sugar that needs digestion.

While this important work of digestion is taking place in the small intestine, another interesting work of equal importance is being carried on there. If we examine the mucous membrane lining of the small intestine, we find that it contains, like the stomach, the little tubelike glands that make the digestive fluid,

and in addition to these a thick covering with tiny fingerlike projections which give it a velvety appearance. These *villi*, as they are called, have a very important work to do. They suck up the digested food, much as the tiny rootlets of a plant suck up its nourishment from the soil. Indeed, the villi may be properly regarded as the "roots" of the body, while the liquid food which bathes the villi is the "soil" out of which the body draws its sustenance just as a tree or plant extracts substances for its growth out of the earth.



THE VILLI LINE THE INTERIOR OF THE SMALL INTESTINE AND ABSORB THE FOOD WHEN IT IS FULLY DIGESTED. THERE ARE 5,000,000 VILLI, AND YOU CAN SEE THAT TAKEN TOGETHER THEY HAVE AN ENORMOUS ABSORBING SURFACE.

We have already learned that all the digested food must be absorbed through the walls of the alimentary canal. The absorbing surface of the small intestine, where this work of absorption chiefly takes place, is very greatly increased by the villi and by folds in the lining membrane. The length of the small intestine is about twenty feet, and its circumference about three inches, dimensions which would give an absorbing surface of about five square feet. By the villi and the folds in the mucous membrane it is increased more than fivefold. There are 5,000,000 villi. Each one of the villi absorbs about two tablespoonfuls of liquid in the course of a lifetime of sixty or seventy years. Try to figure out, in terms of quarts, the total amount of liquid absorbed by all the villi during the course of a lifetime.

The work of digestion and absorption going on in the small intestine is greatly helped by the muscles, as we have found to

be the case in the work of the mouth and stomach. Like the stomach, the intestine has a coat of muscular tissue next to the mucous membrane. By the work of these muscles, the food is kept in constant motion, so that it becomes thoroughly mixed with the digestive juices, and the villi dip into all parts of it to suck up the digested portion. From the stomach downward, the food is moved along the alimentary canal by successive contractions of the muscular walls of the intestines. These contractions are known as *peristaltic movements*, and they occur with great regularity during digestion.

Here is an experiment which will give an idea as to how the food is moved along the intestine: Fill a rubber tube with water. By pinching the tube, the water may be made to move along in it. The peristaltic action or contraction of the intestine in a similar way pushes the food along.

The last food station

The indigestible materials in the food, as well as the wastes formed during digestion and any of the digested food that still remains, is carried from the small intestine into the large intestine, which is not a digestive organ but simply a reservoir for refuse, or a waste receptacle, in which the food residue is retained for a short time before being ejected from the body. As the liquid food is absorbed, the residue becomes more and more solid, and with other wastes is moved forward and finally discharged from the body.

To prevent the wastes and food residues from passing back into the small intestine after they have been pushed into the colon, nature has provided at the end of the small intestine a check valve known as the *ileocæcal valve*. This valve behaves very much like the pylorus. It passes the food residues and wastes into the colon and then prevents their return to the small intestine. Sometimes this valve becomes damaged, and then the waste from the colon passes back into the small intes-

tine, and great harm results. The tongue is likely to become coated, the breath becomes bad, the appetite is lost, the head aches, and the patient often says that he is "bilious," thinking that his liver is not so active as it should be; whereas, the real trouble is that such a large quantity of waste matter is absorbed into the blood that the liver has more work than it can do and becomes exhausted in its efforts to destroy all the poisons which are brought to it from the intestine. Why should the breath become tainted, the appetite be lost, and the head ache when poisons are absorbed into the blood in large quantities?

THIS PICTURE, MADE FROM AN X-RAY PHOTOGRAPH, SHOWS THE LOCATION OF THE COLON.

If the work of digestion has been well done, these wastes and food residues will pass naturally out of the body at regular intervals. The emptying of the colon takes place normally after each meal. It is very easy to form habits in this respect and of great importance that the habits we form should be good ones. It is just as important to discharge the waste products from the body as it is to take in a fresh supply of food. If the drains of a city become choked up, the health of the community is very likely to suffer. The health of the cell communities which form the human body likewise depend upon the prompt removal of all wastes.

The work of microbes

Besides the changes which are made in the food in the intestines by the digestive juices, there are other changes which are produced by microbes. We saw that the acid gastric juice destroyed the germs that found entrance to the healthy stomach. The intestinal juices are

not acid, so harmful germs have a chance to grow and multiply in the intestines. The microbes gradually increase in number from the stomach to the large intestine, which is a very favorable breeding place for germ colonies. Some of these are not only harmless, but even friendly and useful. Others, however, cause the contents of the intestine to decay and to give off very offensive odors and poisonous products that are most injurious to the cells. In a person who is in perfect health and who lives wholesomely, these poison forming germs are not present in sufficient numbers to do harm. But under certain conditions, especially in the case of one who lives unhealthfully, they may multiply to a very great extent, and the poisons they produce may be a cause of serious disease.

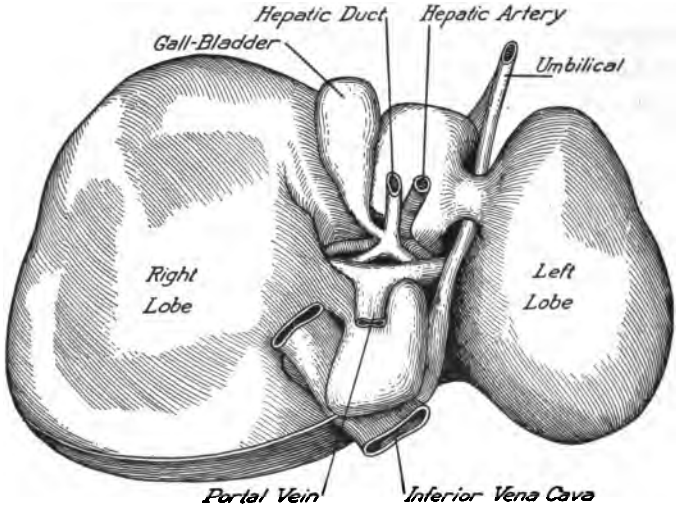
In all cases, the prompt removal of the waste matters in the intestine is a matter of great importance. Headaches and general bad feelings and bad temper may result from the body's being poisoned by the waste matters that have been allowed to remain in it beyond the natural time. The result is that the harmful germs have an opportunity to get a great start. They grow rapidly and the contents of the colon become highly putrid. Gases and various poisons are formed which are absorbed into the blood and give the liver and the kidneys extra work to do. Some of these poisons find their way out through the lungs and cause a bad breath. All the tissues of the body become tainted with the poisons. This is auto-intoxication. Putrefaction in the colon is more active in the cases of those who eat heartily of meat and eggs.

The digested food which is absorbed by the walls of the alimentary canal, in much the same way that a sponge absorbs water, is, in the process of absorption, changed into blood. It then passes into the blood vessels with which the walls of the canal are richly supplied.

On the right side of the body, just outside the alimentary canal, tucked snugly away in a corner by itself beneath the diaphragm, is the liver. The liver is the largest gland in the body, weighing in a man of average size about three and a half pounds.

A wonderful laboratory — the liver

In some respects the liver is the most wonderful organ in the body. It serves the body in more ways than any



THE LOWER SURFACE OF THE LIVER. THE GALL BLADDER ADJOINS IT. THE LIVER IS WELL SUPPLIED WITH ARTERIES AND VEINS. WHY?

other organ, performing at least twenty different kinds of work. We will mention some of its tasks.

Before the food supply in the blood passes to the heart, from which it is to be distributed to the body for the use of the cells, it passes to the liver for final inspection and preparation. The starch, which during digestion was converted into sugar, is changed back by the liver into a kind of animal starch called *glycogen*. In this form it is stored up in the tissues of the liver

until it is needed for body work or heat production, when it is given out as needed, having been first changed back into sugar. In this respect, the liver might be looked upon as a sort of living, automatic stoker, which supplies fuel to the body as needed, just as devices made for the purpose supply coal, as needed, to the furnaces of steam boilers.

The liver also acts as a kind of food inspector for the purpose of protecting the body against poisons. When any metallic poison such as mercury, lead, or arsenic is taken into the blood, the liver absorbs and retains as much as possible of the poison and so protects the rest of the body. Vegetable and animal poisons are also destroyed by the liver.

The liver stores up the vitamines which are necessary for growth. These vitamines are found mainly in milk and in the green parts of plants. They are almost entirely absent from seeds, roots, and meats.

This storing up of vitamines by the liver is especially valuable for young animals and for growing boys and girls. In this way, the process of growth will not be checked if for a day or two one happens to eat food lacking in growth-promoting vitamines. When these vitamines are wholly absent from the food for a long time, an animal not only ceases to grow but its eyes ulcerate, and it soon becomes blind. The Eskimos and other people who live largely upon meat are compelled to eat the livers of seal and other animals to obtain the necessary supply of vitamines. Plants are the original source of vitamines. Spinach and other green stuffs and cows' milk furnish them in abundant quantity.

Do you not think we are fortunate in living in a country in which we can obtain an abundance of good foods containing vitamines, so that we are not obliged to eat the livers of animals to obtain them?

Another highly essential function of the liver is the making of bile. About twenty ounces of this important fluid is made daily by the liver and poured into the intestine just below the stomach. A portion is kept stored up in the gall bladder ready for immediate use when needed. Sometimes, through wrong diet and neglect to keep the colon free from refuse, the gall bladder becomes infected and gallstones are formed, a condition which is often accompanied by very great pain and may require a serious operation for its relief.

The bile does many useful things, of which the most important are these:

(1) It carries off the alkaline wastes of the body, which are highly poisonous and hence must be promptly gotten rid of.

(2) It helps to neutralize the acid liquids which come from the stomach and which would, otherwise, injure the membrane lining the small intestine.

(3) It aids the pancreatic juice in the digestion of food.

(4) It aids absorption.

(5) It hinders the growth of germs in the intestine.

You can well understand, therefore, how important it is to keep the liver in good health, and not to make it work so hard in destroying poisons and removing wastes from the body, that it will become overtaxed and refuse to perform its duties. You can understand also why people become seriously sick when the liver gets out of order. What do you think would be the best way or ways to keep the liver in good working order?

We should mention here that not all the food supply passes through the liver on its way to the heart. A comparatively small portion, especially that which contains the digested fats, is taken from the intestines by small vessels called *lacteals*, which carry it to a duct called the *thoracic duct*, by which it is carried directly to the heart.

The final act in the nourishment of the body is the making of the liquid blood into solid tissues, a change exactly the reverse of that which takes place in digestion. Each kind of tissue takes from the blood the material needed for its own uses and builds and repairs itself. So you see that *assimilation*, for that is what this process is called, is something like creation. It is the building of tissues and organs out of the blood, which forms the stream of life. The blood, in fact, is a sort of traveling market, circulating through the blood vessels as through canals, and from it the nutritive elements prepared in the digestive organs are secured by the tissues wherever they are needed.

Making blood into tissues

Let us now retrace briefly the chain of events which follow each other in the work of digestion, from the time the food enters the body until it becomes a part of it, — built into its living tissue.

In the mouth the food is ground and crushed into a pulp and thoroughly moistened with saliva, which begins the digestion of starch.

It then passes through the esophagus into the stomach, which is a sort of storehouse or preparatory chamber, and the work of protein digestion begins.

Having been thoroughly worked upon by the gastric juice and the stomach muscles, it is passed out through the pylorus into the small intestine. Here the bile formed in the liver is poured upon it for the digestion of fats. The pancreas also contributes its powerful juice, which works upon all three classes of foods, — starches, fats, and proteins. The intestinal juice does much the same work as the pancreatic juice, and in addition it digests cane sugar.

As the digested food is worked upon and carried along by the muscles to the large intestine, it is absorbed by means of the villi lining the intestinal wall. In the large intestine the ab-

sorption of the digested food is completed and the waste matters are discharged from the body.

The absorbed food is carried by the blood vessels to the liver, which completes the work of digesting the proteins or building foods, and regulates the supply of fuel foods to the body, storing up digested starch in the form of glycogen. The liver also extracts poisons and changes them into less harmful substances.

The food supply then passes to the heart, from which it is sent out into every part of the body to be used by the cells for the building up of the living tissues and organs which compose the body.

Health Problems

1. Mention at least five insoluble articles that can be digested, and explain how digestion is possible.

2. Which of your permanent teeth have you now? Which of your baby teeth are you losing? What permanent teeth must you still get?

3. Just where on the tongue are the taste buds situated? What effect would it have on a person if his taste buds should be destroyed?

4. Have you ever had a sickness during which your mouth seemed "dry" so that you could not moisten your food well? How did the food taste? Explain.

5. Do people who masticate their food thoroughly get more pleasure from it than those who swallow it in a half-masticated condition? Explain.

6. Have you ever noticed that when you are sick food will not make your mouth "water"? What is the explanation of this?

7. Do you know why people often crave acid drinks, such as lemonade and the like? Would you expect these to assist digestion? Why?

8. Write a little story about "What Happens to a Mouthful of Bread." Show what interesting things occur until the body is finished with the bread.

Review Questions

1. What work is necessary in order to prepare nutrients so that they can be used by the cells as food?

2. Compare the organs used in digestion with the workers in a bakery establishment.

3. What is the name of the canal through which the food passes? What are its principal parts?

4. What are the digestive juices? How many kinds are there?

5. Of what does the work of digestion consist?

6. Why is mastication necessary?

7. How many teeth does an adult have? Describe each kind and tell its use.

8. What is the saliva, where is it formed, and what is its use? What is necessary in order that saliva may get in touch with one's food?

9. What are the ferments and for what are they used in the body?

10. If one has masticated his food poorly, will he have to make an effort to swallow it? Why?

11. What is the *pylorus?* Describe its work.

12. Describe the "signal system" which nature has provided in the body to help digestion.

13. What happens in the mouth when one sees or smells appetizing food? How does this help digestion?

14. What juice is mixed with the food in the stomach?

15. Suppose you should examine the lining membrane of the stomach, what would you see?

16. How is the amount of gastric juice prepared in the stomach adapted to the needs of digestion?. What is the use of this acid?

17. Describe the muscular action of the stomach. How does this help digestion?

18. How long does it take ordinarily for a meal to pass out of the stomach?

19. Where is the small intestine? How many juices are poured out on the food from the intestine?

20. What organ makes the bile?

21. Where and how are the fats of our food digested?

22. What is the pancreatic juice? What foods will it digest?

23. Describe the villi in the mucous membrane of the small intestine. What is their duty?

24. What is the large intestine? How does it differ from the small intestine in its work?

25. Before the food in the blood passes to the heart, where must it go for final inspection?

26. Just what does the liver do to the food to make it ready for use by the cells? Why is it right to speak of the liver as a kind of food inspector?

CHAPTER IV

Eating for Health and Pleasure

The only part of the important work of nutrition that Nature has left to us is the selection of the food, and the preparation of it for digestion by thorough chewing. All the rest of the work is done for us without any thought or effort on our part. Everything done in the process of digestion, however, is greatly influenced by the manner in which we do our part of the work.

As an aid to us in selecting the food and as an inducement to us to keep it in the mouth until our part of the work is well done, Nature has put into it many kinds of agreeable flavors. When we swallow our foods with little or no chewing, we lose these flavors and miss the pleasure that Nature intended for us in eating.

Digestion depends upon enjoyment of food

One of Professor Pavlov's interesting experiments proved that the amount and efficiency of the gastric juice depend very much upon the enjoyment of the food. The esophagus of a dog was divided and part of it connected with a tube. When the dog was fed, the food, instead of passing into the stomach, dropped out through the opening into a dish. The dog, however, thought he was having a good meal, and the gastric juice immediately began to form in the stomach and continued to pour out as long as he kept on eating and enjoying the food. When he was given food that he did not like, however, there was no outpouring of gastric juice. Also when food was put into the dog's stomach through the opening, without his knowledge, little gastric juice was formed and the food lay there for hours undigested.

The gastric juice that is poured out at the beginning of digestion, as the result of the enjoyment of the food, has been given the name "appetite juice," and has been found to be the most powerful and active juice formed in the stomach. We can see from this that the more the food is enjoyed the better it will be digested. If a person is not hungry, he does not relish his food; and for that reason he will have no "appetite juice" to welcome the food to the stomach and to begin the digestive process.

Those who wish to keep the body in the best state of health should cultivate the habit of chewing the food until all the soluble parts have been dissolved. As a rule, this will be until enough saliva has been poured out to extract from the food all the substances having any taste. In other words, we should chew the food until there is no taste left in it.

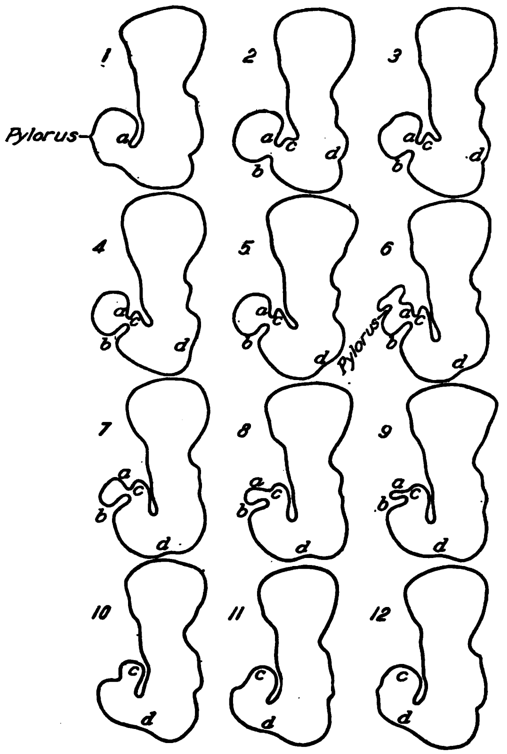
Some causes of indigestion

Bolting or swallowing food without proper attention to mastication is a very injurious though common habit. Many of us are in such a hurry that we prefer to make use of soft foods of some sort that can be easily swallowed without chewing. Moist foods such as mushes and soups cause the flow of only a small part of the saliva that is called forth by the same food in a dry state. It is therefore better that much of our food should be taken dry so as to compel thorough mastication.

It should be remembered, however, that in taking starchy foods which are already moist, mastication is also very necessary for the development of the amount of saliva required for the digestion of the starch. Even such liquid foods as vegetable soups or gruels should be held in the mouth until thoroughly mingled with the saliva. In the feeding of horses, farmers recognize the value of thorough mastication. To secure this, they frequently put a quantity of pebbles into the manger along with the food. The animal is thus compelled to take the food

into its mouth in such small quantities that hasty eating is prevented.

Drinking at meals usually leads to the bolting of food. These two evils are closely connected. Liquids taken with the food diminish the flow of saliva and so interfere with the work of digestion. Very cold liquids are especially bad, because they lower the temperature of the stomach and thus put a stop to the digestive process. A temperature of 100 degrees is required for digestion. It has been observed that a glassful of ice water lowered the temperature of the stomach contents to 70 degrees and that more than half an hour passed before the normal temperature was regained. Hence the whole digestive process was checked for half an hour.



THESE OUTLINES SHOW CHANGES IN THE SHAPE OF THE STOMACH DURING DIGESTION, AS CAUGHT BY THE X-RAY.

Hot drinks, while they excite the stomach temporarily, tend to relax and weaken its muscles and lessen digestive vigor. They also destroy certain useful elements in the saliva. The

highest degree of digestive activity seems to be secured by the use of food at a temperature a little below that of the body, or at its ordinary temperature.

The best time to take liquids is at the close of the meal, when there will be little danger of drinking too much. Fruits eaten with the meal, or at the close, lessen the necessity of drinking at meals. It is not well to try to get along without any liquids when we eat a meal of solid food. Experiments have shown clearly that a glassful of water, not too cold, taken with the meal, helps digestion and enables one to get more good from his food. A wise plan is to take a glassful of cool water a half hour before a meal, and a glassful may be sipped at intervals during the meal.

A variety of food is necessary to assist the appetite, upon which good digestion so largely depends. It is, therefore, important that the food should be varied from day to day or at different meals, as each food supplies the body with some special useful product. The stomach, however, may easily be overworked by a great variety of foods taken at a single meal.

Simplicity in one's selection of food is very important for good digestion. The natural appetite is easily satisfied with a small number of foods, simply and wholesomely prepared. Animals such as the sheep, the goat, and the cow, which in the course of a morning's grazing may swallow one hundred different kinds of herbs, have very complicated stomachs with four compartments. Certain fishes which live on other fish are provided with as many as half a dozen stomachs in which to do their digestive work. Man, with a single, simple stomach, often sits down to a feast which would tax the digestive power of an animal having many stomachs.

The digestion of a meal in the stomach requires about four hours. As you might expect, the stomach then needs a period

of rest before it is ready to undertake the digestion of another meal. Of course, if food is taken too frequently, the stomach will suffer sooner or later, because it will have no rest. You know that the muscles of the arm become wearied by constant exercise, and so do the stomach muscles, which are actively exercised during digestion. "A tired stomach is a weak stomach." When the stomach feels "tired," rest is what is needed, yet many people insist on putting more food into it, thus compelling it to work when it ought to be allowed to rest. Suppose this is kept up; what may happen to the stomach? Have you known of such cases?

A tired stomach

When food requiring several hours for digestion is taken into the stomach before the digestion of the last meal is completed, the stay of the food in the stomach will be so prolonged that the stomach will have no opportunity for rest and clearance before the taking of the next meal. The stomach should be empty for a period between meals, so that the gastric juice may cleanse it and prepare it for the next meal. It has been shown that the glands which prepare the gastric juice become exhausted by work just as do the muscles or any other organ of the body. For this reason, they should have a short period of rest and recuperation between meals.

The number of meals needed daily depends upon one's age and upon the nature and quantity of the food taken at the meals. A baby, who takes only a small quantity of easily digested food at each meal, requires food at frequent intervals. As it grows larger and its meals increase in amount, the interval between meals should be lengthened. By the time it gets its teeth and is able to eat solid food, three meals a day are quite sufficient.

Great numbers of people in the world eat only two meals a day. This is the custom of the natives of India, of South America, and of many semicivilized nations. Among savage tribes,

one meal a day is the prevailing custom. Though the Eskimo hunter sets out fasting in his kayak for a long day's hunt, he eats nothing until after he returns from his perilous work. The ancient Greeks, Hebrews, and Persians ate but two meals a day. It is therefore evident that one can be well nourished on two meals a day. In modern times many persons have adopted this custom with benefit to themselves.

If more than two meals are needed by any group, it is by those who are engaged in severe muscular labor. Such persons are better able to digest a third meal than those whose work is *sedentary*, as we say. If a third meal is taken by sedentary workers, it should be very light.

What has been said about too frequent eating shows that the practice of eating sweetmeats, cookies, ices, nuts, and such things between meals is a very harmful one. It is a certain cause of indigestion, for no stomach can long endure such treatment. By forming this bad habit in childhood, many persons lay the foundation for much suffering from dyspepsia later in life.

Hindrances to digestion

Digestion cannot be well performed during sleep, for then the stomach is very slow in its work. Bad digestion and restless sleep are often the result of late eating. Through the habit of eating just before going to bed, many persons suffer from sleeplessness, bad dreams, and similar troubles, and arise in the morning very dull, because the work of nutrition has been hindered. They usually go to sleep quite readily but are likely to awaken before the night's rest is finished, and are unable to go to sleep again. This is due mainly to discomfort caused by an excess of food and uneliminated waste matters.

Usually no food should be taken within four hours before retiring, except by young children. This will allow time for

the stomach to finish its work and pass the food into the small intestine. Then the work of digestion may be completed without disturbance. If any food at all is taken shortly before retiring, it should be ripe fruit, or fruit juice, which does not require digestion, but is ready for immediate use.

Another cause of indigestion which is closely related to those we have studied, is irregularity in the time of meals. Our bodies try to form regular habits. This is especially true with respect to digestion. If a meal is taken at a regular hour, the stomach will become accustomed to receiving food at that hour and will be prepared for it. If meals are eaten irregularly, the stomach does not know what to expect. The food takes it by surprise, so to speak, and it is never in a proper state of readiness for the prompt and perfect performance of its work. You must remember that the action of the digestive organs, like that of all the other organs, is rhythmical, — that is, it takes place at regular intervals or periods. It is far better, however, to omit a meal than to eat when not hungry, or to introduce into the stomach a new supply of food when it already contains some in the process of digestion, or before it has been given an opportunity to rest.

Instead of omitting a meal when it is not convenient to take it at the regular time, it is well to eat a little fruit, so as to keep up the normal intestinal activity, which is necessary for the proper emptying of the colon. Fruit does not require much work of the stomach and is refreshing and acceptable even when one does not have an appetite for other foods.

Violent exercise, either just before or just after eating, is a hindrance to digestion. It takes the blood away from the stomach to other parts of the body, so that the stomach is deprived of the energy needed for good digestion.

For the same reason it is not well to eat when one is very tired. The energy needed for the work of digestion is lacking

in a person who is in an exhausted condition, and the food is likely to remain in the stomach for some time undigested. If food is needed by one who is very tired, only a small quantity of an easily digested kind should be taken. Nitrogenous foods, such as meat and eggs, are especially harmful to a person who is very tired. Thin, well-boiled gruel, a cup of vegetable broth, or better still, a glass of fruit juice, are the best foods for tired people.

How digestion is influenced by the mind

One should not eat when he is tired; neither should one eat when excited or angry or irritated in any way. Professor Pavlov found that no gastric juice was formed in the stomach of a dog if the animal was annoyed or irritated while eating. Experiments made by Dr. Cannon of Harvard University show that digestion in the small intestine, as well as in the stomach, is greatly influenced by the mental state. He placed a cat under the X-ray, so that he could see the stomach and the intestine. The cat was given some bread and milk containing bismuth, which made the food visible under the X-ray. The digestive juices began to flow, the stomach and intestines began their muscular work, digestion was going on properly, and the cat was purring in comfort after her good meal, until something was done to make her nervous; then purring ceased, and all the digestive work began to slow up. As the cat became very much excited and angry and began to spit, the digestive juices ceased to flow, the muscles stopped work, and the digestive process came to a standstill. The work of digestion stopped entirely until pussy was petted into a good humor.

The mind should be in a cheerful frame while food is being eaten and digested. What sort of conversation should there be at the table? Arguments or disagreements and everything of an unpleasant nature should be carefully avoided. The

ancient custom of having a jester at the table to make people laugh while eating was good for their health as well as for their humor. "Laugh and grow fat" is an old maxim.

The normal guide

A natural and healthy appetite is the best guide as to how much we should eat. If one eats in a proper manner, chewing every morsel until it is liquid, his appetite will guide him in the selection of the food needed and will make known to him when he has had enough of protein, starch, fat, or acid. You already know something about the remarkable signaling system by means of which the digestive

HERE ARE SOME OF PROFESSOR PAVLOV'S DOGS.

work is controlled. The regulation of the appetite is an interesting part of this system. There are certain centers in the brain which have been called "hunger centers." When the body is in need of food, a message is sent up to these hunger centers and from them a sensation is transmitted to the mouth by the nerves of taste, creating the desire for food that we call "appetite." When enough of a certain kind of food has been received into the body, the "hunger centers" are notified that no more is

ONE HAS TO HAVE GOOD HEALTH IN EVERY WAY IN ORDER TO WIN IN A RUNNING RACE. IF HE SMOKES, EATS TOO MUCH, LOAFS INSTEAD OF PLAYING OR WORKING, OR FAILS TO ELIMINATE BODY WASTES REGULARLY, HE WILL LOSE IN THE RACE.

needed, and the appetite for that particular food is cut off. Dr. Pavlov's dogs continued eating with unabated appetite for hours at a time when their food passed into a dish instead of into the stomach. Since no food was received into the body, no message was sent up to the brain to cut off the supply.

When one bolts his food, he cannot discover when he has had enough, for some of the food must get into the blood before the "hunger center" will ring the bell, so to speak, for the supply to cease. When one hurries food into the stomach, he gets more than he needs before the "hunger center" finds it out, and he stops only when he is so full that he cannot eat any more.

Waste in eating

We can now see how some of the bad habits that we have been considering — eating too fast, drinking too much at meals, and taking too great a variety of food at a meal — lead to another bad habit, — that of eating too much. The digestive organs are then overtaxed to take care of a quantity of food that is not needed. All food taken into the body beyond what is needed is not only of no use but is actually harmful. If, in repairing a house, a great deal of unnecessary material were carried into the house, the surplus amount would only be in the way of the workmen, and they would have to spend their strength in carrying it out. It is just so with the little cell workers of the body.

Health Problems

1. Take a slice of bread and chew it until it "swallows itself." How does it taste? Explain.

2. Put your hand into a bowl of ice water; how long can you endure it? How long could you keep your face in it? How do you think your stomach would like to have a bowl of ice water poured into it?

3. Do you know any person who has fallen into the habit of nibbling at food between meals? Describe such a person's health and disposition.

4. Look up the meaning of the word *dyspepsia*. Then make out a list of the eating habits one should form in order to avoid this disease.

5. How would it do for one to acquire the habit of eating breakfast one day at 8 o'clock, the next day at 10 o'clock, the following day at 9 o'clock, and the day after at another hour? Would it make any difference if this irregularity occurred at dinner or at supper?

6. How would it do to jump up from the dinner table and immediately run a long race with a companion? Explain.

Review Questions

1. What has Nature especially provided to induce people to chew food thoroughly?
2. Should food be attractive to the eye as well as to the smell and taste? Why?
3. How long should food be kept in the mouth?
4. What may happen in the stomach if food is not thoroughly chewed before it is swallowed?
5. Why do people so often bolt their food?
6. What is the danger in eating moist foods like mushes and soups? When one eats such foods, what special care must be taken?
7. How do farmers sometimes prevent horses from bolting their food?
8. What bad habit often causes one to drink large quantities of liquids at meals? What is the harm in so doing?
9. What temperature is required for digestion? How will a glass of ice water affect this temperature?
10. What is the harm in taking very hot drinks during meals?
11. If one must drink during meals, how should one do it?
12. Is a variety of food at a meal good for the health? Why?
13. Why is it harmful to eat a meal before the previous meal has been digested?
14. How should the number of meals a day be varied according to one's age?
15. Is there any harm in eating just before going to bed? If food must be taken just before bedtime, of what kind should it be?
16. Is there any harm in eating at irregular times? Why?
17. Is there any harm in taking violent exercise before a meal? Why? What of eating when one is tired?
18. How does the state of one's mind influence digestion?
19. What are the "hunger centers"?

CHAPTER V

Getting Pure Food and Keeping it Pure

In early pioneer days, when our country was young, there were no cities and no factories. People lived far apart, and each family had to depend for its food chiefly upon its own private supplies. The people raised their own grain and had it ground into flour. They made sugar from the sap of maple trees. Their chickens supplied them with eggs, and their cows with milk. Each household prepared foods for winter use by drying, salting, and other means.

But as the country has become thickly populated, most of the people have gathered together in large cities, where it is not possible for them to produce their own foods. So they have to depend upon public supplies for food. The "milk train" comes in from the country early every morning, bringing from the farms the milk supply for a whole city. Our flour comes to us in barrels or bags from distant mills in the grain-growing sections of the country. We must purchase our meats from a public shop or market. Our eggs, butter, canned and dried fruits, and all such articles come from public stores which supply many families. Of course, if you live in the country, you may produce your own vegetables, eggs, milk, and butter; but you probably buy your flour, sugar, fruit, and other foods from public supplies.

So long as each family provided its own food, it was easy to tell whether the food was clean and of good quality. You may know, for instance, that the milk from your own cow is rich,

DO YOU THINK BREAD BAKED IN A PLACE LIKE THIS WILL BE CLEAN AND WHOLESOME? HAVE YOU VISITED THE BAKERIES IN YOUR COMMUNITY TO SEE WHETHER THEY ARE LIGHT AND CLEAN?

fresh, and pure. But the milk you buy from a city store may have had part of the cream removed; it may have had water, coloring matter, or some harmful substance added to it; it may be swarming with harmful bacteria. The bread made at home from wheat grown in your own fields and ground in a hand mill, you know to be wholesome; but the bread you buy at the store may have been made from flour from which the most nutritious portion was removed in the process of milling, and it may have had alum

The adulteration of foods

added to increase the whiteness. It may have been baked in an unsanitary bakery. In some cities, bakeries are carefully inspected. Do you know if this is true of the bakery where your bread is made? You probably know the age of the eggs laid by your own hens; but the "fresh" eggs you buy at the store

PARTICULAR CARE SHOULD BE TAKEN TO KEEP FLOUR FREE FROM DIRT AND ALL ADULTERATION, SINCE BREAD IS THE PRINCIPAL ARTICLE OF FOOD.

may have been laid months before and packed and kept in cold storage.

You see, then, that in getting food from public supplies you run some risk. The articles may not be what they appear to be. Sometimes a cheap substitute is used instead of the real foodstuff. The material used may or may not be harmful; but the food is a counterfeit. This is called *adulteration* of food.

In all countries and in all ages it seems to have been the practice of dishonest dealers to *adulterate* food in order to make more

money through its sale. When Plato, one of the ancient Greeks, was planning a model city, he declared that there should be "no adulteration of food and no tricks of trade."

It is only within quite recent years that people in this country have begun to find out the extent to which adulteration of foods is practiced and the lack of care shown by dealers in regard to the purity of foods sold. Those who look after the health of the people in our country to-day are trying to get a pure food supply for the poor and the rich alike. In most cities now there are food inspectors who try to prevent the adulteration of foods. There is a force of at least one hundred of these food inspectors in New York City alone. Every store in the city is visited twice a month in winter and three times in summer. The great wholesale houses are inspected daily, and a close watch is kept upon the meat markets and slaughterhouses. One result of this inspection is that unfit foods are sorted out and destroyed, and large quantities are being constantly seized.

Harmful coloring matter used in foods

A very dangerous method of adulteration is the use of chemicals to preserve and color foods. Dyestuffs made from coal tar are used to color counterfeit materials. In a little booklet sent out by the United States Department of Agriculture to various schools and colleges, there are samples of cloths presented which have been colored with the dyes secured from such counterfeit foods. One sample is a brilliant cardinal, the dye for which had been obtained from "blood peaches." Another sample is a bright orange, the color of which had come from bottled "orange juice." Still other samples are green and purple, the color for which had been derived from preserved cherries and plums.

Cheap candies very commonly contain harmful coloring matter and other adulterants. Sweetened tallow and grease form the filling of certain chocolate creams. Until a few years ago,

many candy manufacturers used *shellac* for coating chocolates. Then the government forbade its use. The honest manufacturers stopped using it, but the dishonest ones kept on. At a recent New York Pure Food Show, one of the exhibits consisted of three bottles. In Bottle No. 1 there were what seemed to be candy-covered peanuts. In Bottle No. 2 there were the same kind of peanuts after the coating had been taken off; and in Bottle No. 3 was the coating that had been washed off — *four ounces of furniture shellac or floor polish.* Many glossy candies get their polish just as woodwork does, — by a coat of varnish. There was also at the Food Show a jar of candies that had been colored brown with sweetened house paint. One of the exhibits was a doll in gaudy clothes which had been colored with coal-tar dyes obtained from candy and ice cream. How should you enjoy eating your chocolate candies, if you knew you were swallowing floor polish or house paint?

A food inspector, who secured employment in a candy factory in order to find out for himself all about the conditions there, said: "I have seen candy samples brought to the laboratories and boiled down; then rags were dipped in the stuff; and, after the rags were dried, no amount of washing would serve to remove the dye. Imagine putting such material into your stomach and then wondering why you are ill!"

You can try the following experiment for yourself sometime if you think there is any artificial coloring matter in fruit juice, jelly, tomato catsup, or confectioneries. Boil some of the substance; and, while it is boiling, put in a small piece of nun's veiling or a good grade of white woolen dress goods. If the substance dyes the cloth, so that the cloth after having been washed in cold water still has a bright color, this is evidence of the presence of some form of coal-tar dye. A single glass of raspberry soda water such as is found at soda fountains was

recently found to contain sufficient coal-tar dye to color two yards of woolen cloth. Would it be good for one's health to drink this soda water?

Harmful preservatives used in foods

For a long time, certain firms that made a business of preparing foods for sale added such chemicals as *boracic acid*, *benzoate of soda*, *formalin*, *salicylic acid*, and *sulphites* to make the foods "keep" better. These *preservatives*, as they are called, do prevent foods from spoiling. Through their use, dishonest men are able to take garbage gathered from canning factories, — tomato skins, apple parings and cores, worm-eaten and decayed parts cut from fruit, and, after treating them with preservatives and with colorings, to sell them as tomato catsup, apple butter, soup, jam, or mincemeat.

Sulphite of soda and other chemicals are very frequently used in making sausage and Hamburger steak. This is because these preparations are sometimes made of odds and ends of meat which cannot be used in any other way. The butcher often keeps under his counter a large tin can into which he throws the trimmings and odds and ends of meats which are not salable. These are sometimes left to accumulate until the can is full. In the meantime mold and germs grow in and upon the meat, flies visit the can and deposit their eggs which often hatch out into maggots, and so it is no wonder that sausage meat and Hamburger steak, when made by a dishonest butcher from such refuse, contain enormous quantities of germs. Do you know that decaying meats treated with preservatives and then canned and shipped to our soldiers during the Spanish-American war were the cause of a terrible outbreak of sickness and the loss of many lives?

Even good foods chemically treated are likely not to be of much use to the body. The United States Bureau of Chemistry, when Dr. Harvey Wiley was at its head, undertook to test the

matter. A number of young men who were willing to make the test put themselves under certain rules of living. These young men, known as Dr. Wiley's "poison squad," were fed for weeks on foods containing preservatives, and the effects were carefully watched. After long and painstaking trials, it was concluded that all chemical preservatives are more or less harmful when used in foods. Should you expect anything different?

On June 30, 1906, the United States government passed what is known as the Pure Food Law. This does not forbid the use of preservatives and coloring matter in foods, but it requires that when they are used it shall be so stated on the label. This is a protection to those who do not want to use foods with chemicals in them. Do you not prefer foods that have not been treated with such chemicals?

When the housekeeper preserves her own fruits and vegetables, she is careful to use only perfectly sound, fresh products, in which decay has not started. The only preservative that she uses is *heat*. By means of heat she destroys all the germs which cause decay, and then she carefully seals up her jars so that no more germs can enter.

Certain food manufacturers undertook some experiments to find out if it was necessary to use preservatives in food canned for public supplies. They proved that, when sound products are used, no preservatives are needed. The use of any preservative in food is therefore likely to mean one of two things: either that the food products were not of the best quality, or that they were not canned in a careful, clean, and sanitary manner.

There are other ways besides adulteration by which food may be made unsafe. Quite often the bacteria which are the cause of disease get into food through lack of care in handling it or storing it. Sometimes, too, foods contain the poisons which

result from decay. Meat, eggs, and milk are foods especially liable to contain these impurities. All animal foods decay, or, as we say, "spoil" very rapidly. When this process has begun in such foods, some very dangerous poisons, called *ptomaines* and *toxins*, are formed in them. Certain savage tribes poison their arrows by striking the points into the decayed flesh of dead animals.

Careless handling often makes food impure

Canned meats are the most common source of meat poisoning. When the meat is not properly cooked before it is canned, ptomaine poisons are likely to form in the can. These poisons are very deadly. They are much like the venom of snakes, and it does not lessen the danger to cook such food after the poison has formed.

Sausage poisoning or *botulism* sometimes occurs from the use of tainted sausage. Cases of botulism have recently been observed from the use of spinach, beans, ripe olives, and other vegetables. The cause is insufficient heating in canning. No cases of poisoning have occurred from the use of olives canned in small tin cans. When ripe olives are canned in glass jars they may not be properly heated. When beans are "cold packed," they may be imperfectly sterilized. The germ which causes botulism is destroyed by cooking for half an hour at a boiling temperature. For safety, canned vegetables should be thoroughly cooked before serving.

All canned foods when opened spoil more quickly than freshly cooked foods. Why? Canned foods need also to be removed from metal cans at once after opening. Why?

Wholesome eggs must be fresh. Of course, those laid by hens which have been fed on clean foods are safest. It is not uncommon for eggs that have been packed and kept for months to be sold for fresh eggs. If there is any doubt about the matter, one can make a test by holding a suspected egg between the eye

and a lighted candle in a dark room. If it is a new-laid egg, an air space can be plainly seen between the shell and the lining at the larger end. This will be very small in a fresh egg. A large air space shows that the egg is old. If the egg is really bad, a number of dark spots will be seen.

According to government experts, eggs are quite likely to contain germs, even when they are freshly laid. Germs are found on an average in about one egg in seven, consequently freshly laid eggs may contain harmful germs, and should be carefully inspected before cooking or eating.

THE BOY IS TESTING AN EGG FOR FRESHNESS.

Many foods are made unsafe because of carelessness in handling them, and also because of dust and unclean methods in stores. For instance, bread may pass through a half dozen pairs of hands, from the time it leaves the oven until it is delivered at your door. Unless wrapped up it may gather a lot of germs on the way. It is not wise for one to buy food that has been exposed for sale uncovered, whether outside or inside a store. Why?

A *culture plate* exposed under the glass show case in a clean bakery collected only fifteen bacteria in ten minutes, while a plate exposed on the open counter collected 800 bacteria in the same length of time. Fifty times as many germs fell on the

THERE SHOULD BE A "WHITE LIST" OF STORES IN EVERY COMMUNITY AND SUPPLIES SHOULD BE PURCHASED ONLY FROM STORES ON THE LIST. DO YOU NOT THINK THAT ALL STORES WOULD TRY TO KEEP CLEAN IF EVERY TOWN HAD A "WHITE LIST?"

Uncleanliness means danger

exposed plate as on the one protected by the glass show case. On the same day, plates were exposed on a sidewalk fruit stand, and in ten minutes 10,000 bacteria were collected, while a plate exposed under a glass cover collected only forty-one bacteria in the same length of time. So the food exposed to the dust of the street contained 250 times as many germs as that protected by a cover. For similar reasons, in sweeping a dining room, all

the dishes and food should be carefully protected. If this is not done the dust containing germs may easily become mixed with the food and do more or less harm.

A group of women in a city that I know devised the following plan to get clean, safe foods. They examined every store where foods were sold and made what they called a "White List." Every salesman who was found to keep his store clean and sanitary was given a big placard bearing the words "White List" to put in his window. This showed to everybody that the foods of that store might be eaten without danger to anyone's life. The women agreed to buy their foods only at stores enrolled on the "White List." You can imagine what a cleaning up time there was. Clean hands, clean aprons, well-protected food, and a city full of neat and well-kept markets resulted from this campaign.

Intense cold checks the growth of bacteria, while intense heat kills bacteria. Drying also removes the moisture necessary for germ life. All these methods are used to preserve food. Storage in some cold place is the most common method of keeping fresh foods like fruits, vegetables, meats, milk, and eggs. Some of the methods for keeping the food cool are by suspension of the food in deep wells, storage in cool cellars, covering with ice water, the use of porous containers hung in a current of air, the placing of the food in closed vessels which are then covered with wet leaves or buried in wet sand. Why should each of these methods be useful?

The best device for preserving foods by cold is an ice box or refrigerator, such as you have all seen. But in the use of the refrigerator there is need for great care and cleanliness. My little friend Jane has the care of the refrigerator for her share of the home work. She keeps strict watch of the iceman to make sure that he washes the ice before he puts it into the box.

GREAT CARE SHOULD ALWAYS BE TAKEN TO KEEP THE ICE BOX CLEAN, SWEET, AND WHOLESOME. THE ICE SHOULD ALWAYS BE WASHED BEFORE IT IS PUT INTO THE BOX.

IF THE ICE BOX IS NOT THOROUGHLY CLEANSED AT LEAST ONCE A WEEK, IT WILL BE DIFFICULT TO KEEP THE FOOD MOIST AND WHOLESOME.

She knows that if it is lake or river ice it may have in it fragments of grass or leaves which, as the ice melts, may cling to the box or water pipes. So once each week she takes out all the ice, wrapping it in newspapers to prevent waste. Then she removes all the food from the ice box and covers this from dust. Next she scrubs out the ice compartments and cleans the drip pipe through which the water flows away. This she scalds with a strong solution of boiling *sal soda water*. She takes out the shelves and scrubs them well in a pan of hot soapsuds. After rinsing them she dries them.

How Jane cleans the refrigerator

She gives careful attention to all parts of the food chamber. She even scrubs the water pan. When every part is clean and dry, the ice is put back, the shelves are replaced and the doors closed. As soon as the temperature within is cooled to 50 degrees, the food, too, is put back. Do you wonder how Jane knows when the box is cold enough? She keeps a thermometer inside the refrigerator all the time, for she has found that the foods spoil in a refrigerator which has become warm, even more quickly than when they are kept outside in warm air. A thermometer is the best means of testing the temperature within the refrigerator. Jane tries always to keep it at about 45 or 50 degrees. Occasionally the ice gets very low. Then she takes the food out until the iceman brings a new supply of ice, and the air in the food chamber becomes cold again. Meanwhile, the foods are kept cool in some of the other ways of which mention has been made. The next time she gets more ice, or takes better care of the ice so that it will not melt so fast.

Before storing foods in the ice box, Jane always puts them in clean dishes. Anything spilled in the food chamber is wiped up at once. Foods are not put in while they are hot or while giving off steam. Of course, the food chamber needs more frequent

cleaning than the ice compartment. Every day Jane wipes the shelves; and once each week, or oftener in warm weather, she gives the food chamber a thorough cleansing.

Health Problems

1. Ask your father and mother whether they buy more of their food from public supplies than their parents did. If there is a difference, what has caused it?

2. Are there food inspectors in the community in which you live? If so, how many of them are there? Just what do they do? Have you known of their destroying any foodstuffs?

3. Can you tell by the naked eye when the foods bought at stores are adulterated? Take canned fruits, for instance; how can you tell when they are adulterated as to color or flavor or quality?

4. Can you tell when candies are adulterated? How? Make a test of some cheap candy bought at a store, and give the results to the class.

5. If you can, get some small samples of *boracic acid*, *benzoate of soda*, *formalin*, *salicylic acid*, and *sulphite of soda* to show the class. Why do they preserve food?

6. Do you know whether chemical preservatives are ever used in your family in canning fruits or vegetables? Ask your mother whether she thinks she can put up goods that will keep without using any of the chemicals mentioned above.

7. Have you ever heard of any one's being poisoned by eating canned meat or fish? Do you know whether oysters are likely to contain ptomaines?

8. Visit a bakery in your town or city, and tell the class what you think about the methods used to keep the food clean and pure. Are the persons clean who do the baking?

9. Visit a meat shop in your town or city, and tell the class whether the butcher takes pains to keep his meats pure and clean.

10. Is there a "White List" of stores in your city? If not, would it be well to have one? Why?

11. Look into your ice box when you go home, and say whether you think it is a thoroughly wholesome place in which to store food.

Review Questions

1. How did each family get its food in the early pioneer days?

2. Where do people in the city get their food to-day?

3. Explain how we secure the different articles of food which we use.

4. Why is it difficult for people to-day to tell whether their food is pure?

5. Why have food inspectors been appointed in large cities, and what is their work?

6. What does it mean to *adulterate* food? Why do men adulterate food?

7. Do the inspectors find much food that is not fit to eat? What do they do with it?

8. What is a common method of adulterating canned meats?

9. What is a common method of adulterating honey and jelly?

10. Tell about the adulteration of food with tar dyes.

11. Describe especially the methods of adulterating candy.

12. What experiment can you make to determine whether there is coloring matter used in fruit juices, jelly, or confectionery?

13. Are coal-tar dyes harmful when taken into the stomach?

14. What is the Pure Food Law? Is it necessary to have such laws in this country?

15. When a manufacturer must use a chemical preservative, what is probably true about the quality of the fruit or vegetables he cans?

16. What is the name of the poison which is sometimes found in canned meat, or in fish or oysters?

17. When poisons have been formed in a can of food can you purify the contents by boiling? Why?

18. How soon after a can is opened should the contents be emptied?

CHAPTER VI

The Blood

More than a century ago a great English scientist, John Hunter, performed some interesting experiments. He cut the nerve trunk that supplied the limb of an animal and then watched the results. The limb was paralyzed, but the flesh remained warm, the circulation continued, the hair and nails grew as before, and so the limb remained alive. The muscles shrank for want of use, but otherwise no evidence of disease appeared. An experiment was then made with another limb. The arteries conveying the blood to the part were tied, while the nerves were left undisturbed. Note the different result. Within a few hours the limb became cold. It became also livid, purple, and finally black. Soon the flesh began to fall away. The limb had died and had become simply a decaying mass. These experiments clearly showed that it is the blood that maintains the life of the tissues through which it flows. The blood constantly replaces the worn-out cells and fibers, so that by its agency the body is continually renewed.

The blood renews the body

The eyes with which we look out upon the world to-day are not composed of just the same cells as those which pictured for our brain the happenings of the outer world a year or two ago. The muscles which move us about and the brain and nerves with which we think and feel are likewise new. All the soft parts of the body are so rapidly changed that the great mass of the body is renewed every few months or, at the longest, every few years.

It is by means of the blood that this body rebuilding is constantly carried forward.

The blood has been called the "carrier" of the body. It receives the digested food from the alimentary canal and the oxygen from the lungs and carries them to the waiting tissues in all parts of the body. The smallest cell, no matter how far removed from the great centers of life, receives its due share of nutriment through the medium of the blood. In return for the new material which it supplies to the tissues, the blood carries away the cell wastes to the organs by which they are expelled from the body. Is this constant exchange of matter in the body essential to life? Do you think that the more rapidly old material is carried away and new material deposited in its place, the more rapidly the wheels of life will turn and the more one will really live?

As you look at blood it appears to be red, but when you examine it under the microscope, it no longer looks red. It is then seen to be filled with very small forms known as blood cells or *corpuscles*.

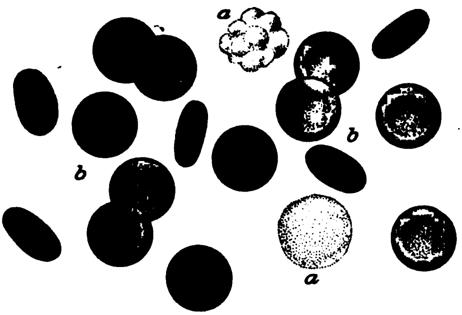
The blood cells, red and white

The number of these cells is so great that a very small drop of blood contains more than five millions, and the number contained in the body of an average man is twenty-five million millions, — 25,000,000,000,000. In other words, a man has in his body more than twelve thousand times as many individual blood cells as there are people on the earth. The blood cells are so small that it takes from 2500 to 3500 to make a row an inch long; but their number is so great that the blood cells of a man arranged in a single row would reach four times around the earth. Spread out flat and arranged as closely together as possible, the red blood cells would cover more than half an acre.

Each of these little cells is a distinct living creature, but its

period of life is only about six weeks. Consider for a moment the significance of this. Twenty-five million millions of blood cells must be created every six weeks. This requires the making of blood cells at the rate of more than seven millions per second. At every tick of the clock, seven million blood cells die, on the average; and seven million more must be created to take their places. Do you see what a wonderful factory the human body is?

A close look at the blood cells under a microscope will show that they are of various shapes and sizes. The smaller ones are the most numerous. They have the shape of flattened, biconcave (concave on both sides) disks, and are of a faint amber color. These are the oxygen carriers of the blood.



THERE ARE TWO KINDS OF BLOOD CELLS, (*a*) WHITE AND (*b*) RED. A SMALL DROP OF BLOOD CONTAINS ABOUT FIVE MILLION. SEVEN MILLION NEW CELLS ARE CREATED EVERY SECOND. THE PICTURE SHOWS GREATLY MAGNIFIED CELLS.

They carry from the lungs to the tissues the life-giving oxygen upon which every function of the body depends. It is by means of a pigment they contain called *hæmoglobin*, which gives to the blood its red color, that the red cells are enabled to carry oxygen. The same cells collect the poisonous carbonic acid gas and carry it back to the lungs where it is thrown off.

The time occupied by the passage of the blood through the lungs is very brief, only a few seconds; yet this is sufficient for the unloading of the poisonous carbon dioxide, which is received from the tissues, and the taking on of a fresh load of oxy-

gen. The lungs may be regarded as the chimney of the body, — the carbonic acid gas is the smoke, and the oxygen is the air which comes in through the draught; thus the lungs serve the purpose of a draught as well as that of a chimney. Suppose that a stove were constructed with but one opening for the inlet of air and the outlet of smoke. The fire might be started in such a stove, but it would quickly be smothered by the accumulation of smoke, which would prevent the entrance of fresh air. The same thing would happen to the body were it not for the red blood cells. These carry in the fresh air, the oxygen, and assist in carrying out the smoke, just as men might carry into a laundry buckets of pure water and carry out the dirty water resulting from the washing process.

The white blood cells show many different sizes and shapes. In the resting or quiet state, the white cells are transparent spherical forms, resembling jelly drops, which float in the blood stream. They are able to move, like the amœba of the pond, by changing their form, — stretching themselves out into elongated shapes and gathering themselves together again as a worm does.

The white blood cells

The red cells do not leave the blood vessels, but the white cells have the power to pass through the walls of the capillaries, leaving no gap or opening behind them. Just how they accomplish this is one of the mysteries of science.

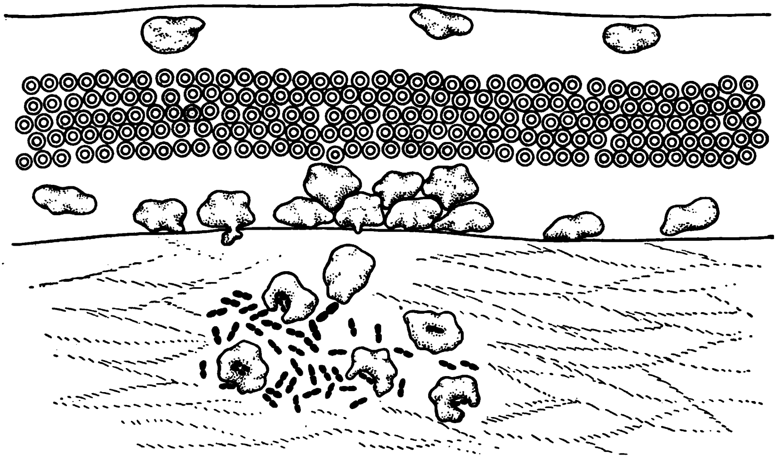
The white cells of the blood have been well called the "Army of the Interior," because they are the defenders of the body against disease and other dangers. Every human body is guarded and defended by a countless host of these little living soldiers, some of whom guard the walls and fortifications, while others like "flying columns" move about freely to spy out the enemy and attack him at whatever point he appears. They seem to have no generals and no commander-in-chief, yet in their

unity and harmony they might well serve as a model to the great armies of the world. They possess powers superior to those of the most experienced veteran of any army. They never sleep, but keep constant watch day and night and seem to detect by instinct the approach of an enemy. They are able to change their form and to assume the form most suitable for their object. More wonderful still, they are able to penetrate the walls of blood vessels and other tissues without difficulty. The law of their being is that they must conquer or die, and they frequently do lay down their lives in great numbers to save the body which it is their business to defend.

The defensive and healing power of the blood cells

Each cell seems to have a peculiar intelligence by which it is unerringly guided to the place where it is needed. Suppose, for example, a few germs are introduced into some transparent tissue (tissue one can see through), such as the web of a frog's foot or the wing of a bat. What happens may be noted with a powerful microscope. Watching closely, one may see the white cells beginning to accumulate on the inner wall of the blood vessel, just opposite the mass of germs. The cells move more and more slowly, creeping carefully along, as one often sees a dog tracking his master or game of some sort. By and by the moving mass of cells comes to a stop. Then each cell begins to push out a tiny thread of its own tissue, thrusting it through the wall of the vessel. Little by little, the farther end of the delicate filament which has been pushed through the wall grows larger and larger, while the portion within the wall becomes smaller. After a little time each cell is found outside the vessel, yet the vessel wall remains as perfect as before. Apparently each cell has made a minute opening and has then tucked itself through, as one might tuck a pocket handkerchief through a ring.

Once outside the blood vessel, the body defenders, moving here and there, quickly discover the germs and proceed at once to devour them. This they do by inclosing them or surrounding them with their own little bodies. If the germs are few, they may soon be destroyed in this way, for the white cells not only swallow germs but digest them. If the number is very great, however, the cells sacrifice themselves in the effort to



WHENEVER THE BODY IS INJURED OR IS ATTACKED BY GERMS THE WHITE BLOOD CELLS COME TO THE RESCUE TO DESTROY THE GERMS OR HEAL THE WOUND.

destroy the germs, taking in more than they are able to digest and destroy. When this occurs, the germs continue to increase; more white cells make their way out of the blood vessels, and a fierce and often long-continued battle is waged between the body defenders and the invading germs. From all parts of the body, white cells hasten to the scene of the conflict until the number may be so great as to cause a swelling of the part where the battle is in progress. It is in this way that a boil or an abscess is formed, and the "pus" which is discharged consists

of the dead white cells which have laid down their lives in defense of the body. The number of cells which may be sacrificed in such a battle, when it is waged day by day, may be shown from the fact that a single ounce of pus may contain as many as 100,000,000,000 of these fighting cells which have died in their efforts to repel the invading germs.

When any part of the body is injured, white cells accumulate in great numbers. They spread themselves over the surface of the wounded parts and dexterously weave a new fabric to cement the ends of a broken bone or to cover a surface which has been made bare. In the formation of new covering for a surface from which the skin has been removed, we see the creating, healing process which by means of the blood is being continually carried on in the body.

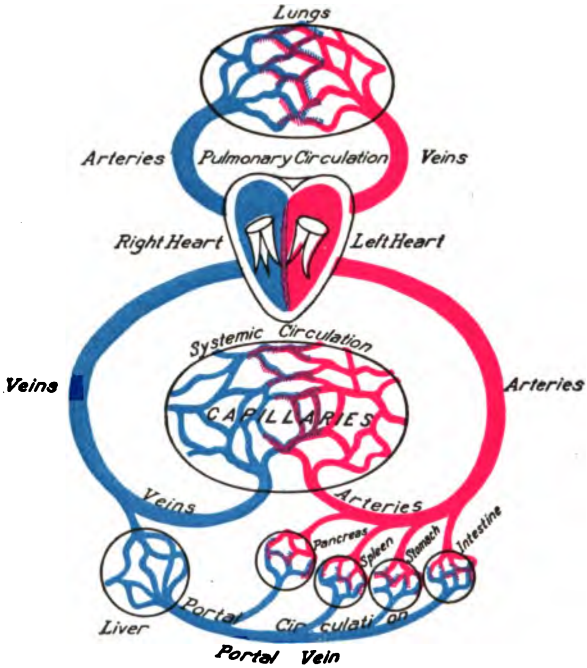
If you would like to see this illustrated, watch the healing of a cut. The blood forms a clot in the opening; and if you could examine the clot through a microscope, you would find a perfect network of little strings or fibers, like the wire cables used in the building of a bridge, running from one side of the cut to the other. Soon you would see, creeping out on those threads to begin the work of repair, some thousands of white blood cells. They build up the blood vessels and nerves and fill up the space with new tissue to heal the cut.

Some of the white cells act as scavengers, going through the body and gathering up materials that are no longer of any use and conveying them to places where the body may get rid of them. There are various sorts of white cells, each of which probably has its own special work to do; but this is a question concerning which very little is known. Do you not see how really wonderful this body of ours is?

The fluid portion of the blood in which the cells float is called *plasma*. This is composed chiefly of water in which the digested

food elements are dissolved. It contains also gases and other poisonous products discharged into it by the tissues.

It is necessary for the activity of the blood cells and the tissues that the blood should be in an alkaline condition. The degree of alkalinity of the blood changes considerably. The absorption

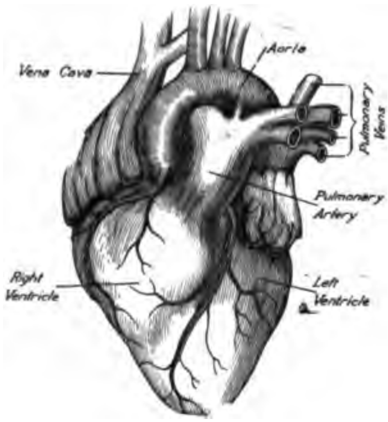


WITH YOUR PENCIL, TRACE THE COURSE OF A DROP OF BLOOD FROM THE TIME IT LEAVES THE RIGHT HEART UNTIL IT RETURNS TO THE RIGHT HEART AGAIN. TELL WHAT HAPPENS TO THE DROP OF BLOOD OR WHAT IT DOES AT DIFFERENT POINTS IN ITS COURSE.

of acid waste substances from the tissues lessens this alkalinity. It is also lessened by sedentary habits, by neglect to take proper exercise, by impure air, by the use of alcohol, and in various diseases, especially in diabetes. Certain articles of food, notably meat, which contain uric acid, may lessen the

alkalinity of the blood. This is a matter of great importance, for the reason that the blood plasma, like the white corpuscles, when in a state of health has the power to destroy germs. But when its alkalinity is lessened by the causes mentioned, this power is to some extent lost. As a result, the power of the body to defend itself against intruding germs is actually destroyed.

We have seen that the blood is the carrier for the body, and therefore it must be kept in constant motion. It used to be thought that the blood simply moved back and forth in the blood vessels, as the waters of the sea ebb and flow. But in 1621 an English physician, named William Harvey, discovered that the blood circulates, flowing in the blood vessels like a stream, always in one direction, and returning to its source, or starting place.



THERE IS A RIGHT HEART AND A LEFT HEART. WHY IS SUCH AN ARRANGEMENT NECESSARY? NOTICE HOW WELL THE HEART IS SUPPLIED WITH ARTERIES AND VEINS. WHY?

The heart and the blood vessels

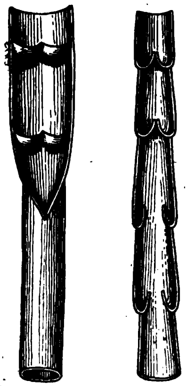
It has been shown by experiments upon animals that all the blood in the body passes through the various organs hundreds of times in the course of a single day. By what wonderful machinery is this rapid and constant circulation of the blood accomplished?

The chief power which causes the circulation of the blood is the beat of the heart. Some organs of the body perform several different kinds of work; but the heart has a single purpose, — that of keeping the living stream of life always flowing through the body, bathing every cell and tissue, feeding

every organ, washing away waste particles, and carrying them to the outlets of the body.

The heart is a hollow muscle about the size of the fist, situated just behind and to the left of the upper and middle portion of the breast bone. Its shape is conical. As it contracts, its *apex* taps the chest wall at a point just below the fifth rib, where its movements can be felt easily.

The heart is double; or, rather, there are two hearts, a right heart and a left heart, almost identical in form. There are valves in the heart, very similar to those in a pump, so arranged that when the heart contracts, emptying itself, the blood forced out cannot return. A very ingenious check-valve arrangement relieves the heart of the pressure of the blood which has been forced out of it, as you can see in the illustration.



HERE ARE SHOWN CHECK VALVES IN THE VEINS. WHY ARE THEY NEEDED?

By placing the ear at a point below someone's fifth rib, about two inches to the left of the breastbone, where the heart movements are felt, one may hear, every time the heart beats, two distinct sounds, which resemble the syllables, "lub-dup." These sounds are produced by the movement of the heart and the closure of its valves, and are like the thumping and clicking sounds which accompany the action of a water pump.

The organs used in the circulation of the blood are not confined to the chest alone, but extend throughout the whole body. They consist of the central part, or heart, and two sets of branching tubes connected with it. One of these sets of tubes starts at the right heart, the other at the left heart. The system which begins at the left heart extends throughout the body, ending at the right heart; the one which begins at the right

heart is distributed to the lungs only and ends at the left heart, as shown in the picture.

In each set of tubes there is a main tube starting out from the heart, dividing into many branches, which, after becoming very small, combine to form larger ones, finally making large trunks, which again join the heart. The tubes leading out from the heart are called *arteries;* those which lead back to the heart are called *veins*. The minute vessels which join the arteries and the veins are called *capillaries*.

The walls of the arteries, and to some extent also the walls of the veins, are muscular and hence are able to contract. The walls of the arteries and veins are thick and strong; the walls of the capillaries, however, are extremely thin, far more delicate than the finest gossamer silk. They are transparent, so that by placing under a microscope a bit of thin tissue, like the web of the foot of a living frog, one may easily see the blood moving through these minute vessels and may study their rhythmical contractions. By means of the X-ray it is also possible to study the movements of the heart.

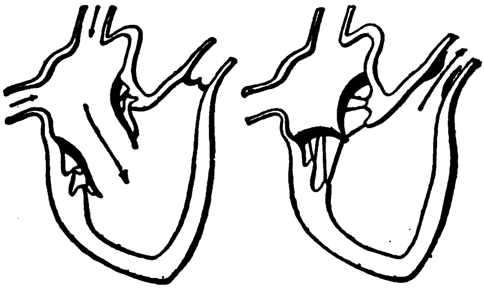
The three systems of circulation

The left heart works to supply the body with blood for the building up of its tissues. The right heart works for the purpose of pumping the blood which has gathered up the poisonous wastes from the tissues to the lungs for purification. The blood that goes from the left side of the heart through the arteries is returned through the veins to the right side. It is then pumped to the lungs by the right heart, and, after purification, it is returned from the lungs to the left heart.

The blood thus passes through two circuits; the larger of these, starting with the left side of the heart and ending with the right side, is termed the *systemic circulation;* the smaller, starting out from the right heart and ending with the left heart, is called the *pulmonary*, or lesser, *circulation*.

Each heart is divided into two compartments, one which receives the blood and one which sends it out. The receiving compartment is called the *auricle*, from its resemblance to an ear; the compartment which forces out the blood is called the *ventricle*.

A volume of blood equal to the total amount contained in the body passes through each side of the heart about once every minute. Some portions of the blood, however, complete the circuit in about half this time. The blood travels in the arteries very rapidly, but in the capillaries the blood movements are so slow as to be almost unnoticeable. The length of the capillaries, however, is so very short that the time occupied in passing through them is brief.



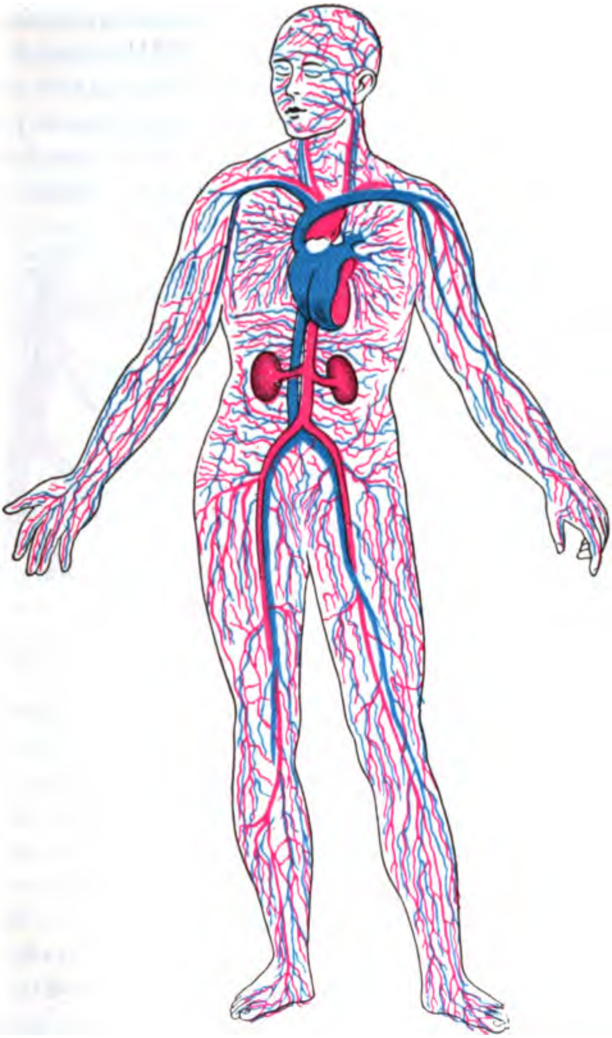
Positions of valves before the contraction of the ventricle

Position of valves at the beginning of the contraction of the ventricle

THESE DIAGRAMS SHOW THE ACTION OF THE VALVES OF THE HEART.

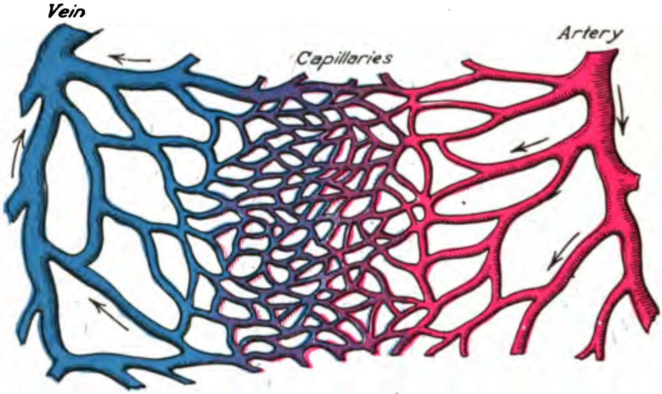
It has been calculated that the capillaries of the body can hold several times as much blood as the arteries. This partly accounts for the slow movement of the blood in the capillaries.

The blood travels much more slowly in the veins than in the arteries. Its force in the veins is also very much less, a condition which accounts for the fact that when a vein is cut the blood flows with a slow, steady stream; whereas when an artery is severed the blood spurts out in jets and with considerable force. The veins differ from the arteries in that they are supplied at various points with check valves, which prevent a backward movement of the blood, as shown in the illustration on page 80.



EVERY PART OF THE BODY IS SUPPLIED WITH ARTERIES AND VEINS. IN THE PICTURE SHOW WHERE THE BLOOD STARTS FROM IN ITS COURSE ABOUT THE BODY. DOES IT ALL COME BACK TO THE SAME PLACE SOONER OR LATER?

The blood of the pulmonary or lung circulation starts, as we have learned, from the right heart and goes to the lungs for purification. In the lungs, the blood is spread out in a fine capillary network, distributed in the membrane lining the air passages and air cells, and extending over an area which has been calculated to be about one thousand square feet. After passing



THE CAPILLARIES ARE THE CONNECTING LINKS BETWEEN THE ARTERIES AND THE VEINS. WHY DOES THE COLOR OF THE BLOOD CHANGE AS IT PASSES THROUGH THE CAPILLARIES?

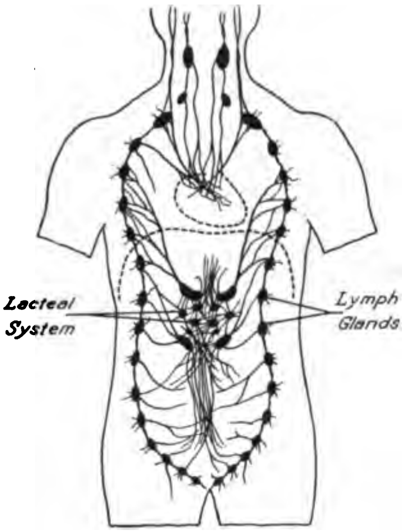
through the lungs, the blood is returned to the left heart to be sent throughout the body again. So it goes on hour after hour, day after day, and year after year, as long as one lives.

The portal circulation

The portal circulation is a remarkably interesting arrangement of blood vessels connected with the digestive organs and the liver. The blood which is supplied to the stomach and intestines and other organs connected with the work of digestion, on entering the veins, does not return at once to the right heart, as does the blood from other parts of the body, but is carried to the liver, in which it is again distributed through a set of capillaries so that it may be brought into contact with the living cells of the liver. The liver cells are thus afforded

an opportunity to remove impurities that may have been absorbed from stomach or intestines and also to act upon the several elements of the food. This gives the liver an opportunity to change the sugar that has been digested into glycogen and to store it up for use as body fuel and also to deal with the surplus protein which may have been eaten, by turning it into waste for the kidneys to eliminate.

The thin walls of the capillaries permit the escape of a considerable portion of the blood into the tissues. In other words, there is a constant leakage from the blood vessels. This escaped blood is called *lymph*.



THE LYMPHATIC GLANDS GATHER UP THE BLOOD ELEMENTS THAT ESCAPE THROUGH THE CAPILLARIES. THE GLANDS ACT AS FILTERS, DETAINING GERMS SO THAT THE WHITE CELLS MAY DESTROY THEM.

The lymph

The lymph is the means of communication, or "middleman," as it has been called, between the tissues and the blood. All the cells of the body are bathed in lymph. They live in lymph just as a fish lives in water or as the body as a whole lives in the air. They take up from the lymph the nourishing substances which escape into it from the blood, and discharge into it their waste matters.

The pressure within the blood vessels prevents a return of the lymph into the circulation. Consequently, particular provision is made for the gathering up of these escaped blood elements into a special set of vessels called the *lymphatic system*.

There are located along the lymph vessels at certain points small bodies called *lymphatic glands*. The vessels do not pass through these glands, but empty themselves into the glands which are drained by vessels on the opposite side. The lymph is therefore passed along from one to another of a series of glands, until it finally reaches a point in the center of the body near the heart, where the various lymphatic vessels converge and discharge their contents into the large veins.

A LYMPH GLAND IS HERE SHOWN GREATLY ENLARGED.

The battle in the lymph glands

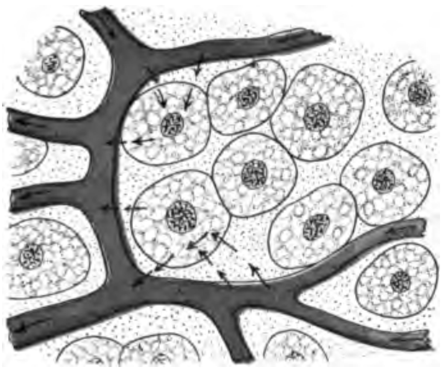
Germs which enter the body through the skin and find their way into the lymphatics cannot reach the deeper and vital parts of the body without "running the gantlet" of many lymphatic glands, which act as filters, detaining the germs and giving the white cells of the blood, which are always present in these parts in great numbers, an opportunity to destroy them. The lymphatic glands are placed in great numbers in those parts of the body where germs are likely to enter. It is for this reason that they are so numerous about the neck.

How the blood is circulated

Having studied the several routes by which the blood travels in the body, we may next notice how it is made to travel along these channels. The impulse is given to the blood movement by the heart, which contracts with sufficient force to elevate the blood to a height of several feet in a tube connected with a main artery. The total amount of work done in twenty-four hours by the heart of the average man, in its contractions, is equivalent to lifting one hundred

and twenty-four tons one foot high, or to lifting a hundredweight one foot high 2480 times, or four times a minute for ten hours.

Even the expenditure of this amount of energy is not sufficient to maintain the movement of the blood current. Other forces are brought into operation which greatly assist this important work. The circulation is aided by the rhythmical contractions of the small arteries and capillaries, which force the blood onward in a steady stream into the veins. The movements of the body produced by contractions of the large muscles of the limbs and trunk aid the circulation by compressing the veins and thus forcing the blood forward; a return flow is prevented by the valves of the veins. The breathing movements, as we shall see later, produce a sort of suction action in the chest which draws the blood toward the heart.



THE LYMPH IS THE "MIDDLEMAN" BETWEEN THE TISSUES AND THE BLOOD.

The beating of the pulse goes on steadily from birth to death without any interruption. How is this possible, since the heart is a muscle and the muscles require rest? An explanation is to be found in the fact that the heart takes a short rest at the end of every beat. A careful study of its action shows that it spends nearly half its time resting.

The rate at which the heart works varies with many conditions. On counting the pulse at the wrist, the ordinary rate in an adult sitting upright is found to be 68 beats in a minute.

In the same person lying down the pulse rate will be found to be 64 beats, and in the same person standing the rate will be increased to 78. Why this change? Walking at a moderate rate usually raises the pulse to about 100, and by running and other violent exercise, it may be increased to 180 or even more. The pulse rate of an infant is 130 to 140; that of a child of ten years, 90. In aged persons the pulse rate is found to be from five to ten beats faster than in middle age. In fever the pulse rate is increased one fourth or more and is sometimes even doubled.

How the blood supply is controlled

The blood supply of the body in general is regulated by the heart; but each particular part of the body also requires some special regulation of the quantity of blood supplied to it. This is brought about by means of nerves similar to those which control the action of the heart. Through the influence of these nerves, the muscular walls of the blood vessels are made to contract or dilate as may be necessary. If more blood is required, the vessels dilate, thus widening the channel and increasing the supply. If less blood is needed, the vessels contract, thus diminishing the size of the channel through which the blood must flow. These nerves are brought into action when cold, heat, friction, or other stimulants are applied to the skin.

Cold causes contraction of the walls of the blood vessels; while heat and friction or other irritants dilate them. The contraction from the effect of the cold, however, is quickly followed by a dilatation, or so-called reaction. The dilatation produced by cold differs from that caused by heat, in that it is more permanent and is accompanied by an active movement of the arteries, whereby an increased amount of blood is pumped through the dilated vessels. Heat apparently dilates the veins more than the arteries and does not increase the activity of the

blood current through the skin. It is for this reason that heat gives to the skin a dusky red hue, while the reaction produced by a short application of cold produces a crimson red color. Prolonged cold produces a bluish color, by so contracting the small vessels that the movement of the blood through the skin is almost entirely prevented. The little blood that remains in the veins becomes so thoroughly charged with carbonic acid gas that it acquires a deep blue color, which gives the blue tinge to the skin. Why are your hands red after they have been used in snowballing, and blue when they are numb with cold?

Health Problems

1. For purposes of experiment, tie a string tightly around your finger and leave it there for a few minutes. Describe what happens to the extremity of the finger. Suppose the string should be left there permanently; what would happen to the finger? Why?

2. Show why it is proper to speak of the white blood cells as the "Army of the Interior."

3. Mention some of the common enemies of the body that would destroy it if the white blood cells were not always on guard and in good fighting condition.

4. What is the meaning of *sedentary?* Mention any sedentary habits that persons have whom you know. What do such persons need to do in order to keep in good health?

5. Mention some fluids that are alkaline. How can you tell whether they are alkaline or not?

6. Locate your heart precisely. Point out exactly where it "taps the ribs."

7. Suppose the valves of the right heart should become weakened, what would happen to the body? Suppose the valves in the left heart should become weakened, what would happen?

8. Can you illustrate the arteries, veins, and capillaries in your body by comparison with the streets of your city? Are there any streets that you might call arteries, others capillaries, and others veins? Why? Can you speak of arteries, capillaries, and veins in a plant or a tree? Why?

9. Why are the capillaries so fine? Why should they not be so large as veins?

10. Does the heart work harder in a man seven feet tall than in one four feet tall? Explain.

11. Why does the heart work faster when one is climbing stairs or running than when he is standing still or sitting?

12. Show the checks in your own veins. Which way with regard to the heart do you have to push the blood in order to show these veins? Why?

13. When one's feet are cold or when he has a headache, why does he take a hot foot bath? Why should one take a cold shower bath immediately after a hot bath?

14. Write a story entitled "The Traveling Market" to show all the work that is performed by the blood.

Review Questions

1. What is it that maintains the life of the tissues of the body?

2. Are the cells that compose any organ constantly changing? How do we know?

3. What is the carrier of the body? What does it carry, and where does it carry it?

4. What is the meaning of *corpuscle?*

5. How many blood cells in a drop of blood?

6. If all the blood cells in the body were put together in a row how long a line would they make?

7. How rapidly are blood cells made in the body?

8. How do the red blood cells look under a microscope? What is their function?

9. How do the white blood cells look under a microscope? What is another name for the white blood cells? What is their function?

10. Suppose there are not enough white blood cells in the body when it is attacked by germs, what may happen?

11. How is a boil, an abscess, or pus formed?

12. How does the blood heal wounds?

13. Describe the work of the plasma.

14. What is the meaning of "circulation of the blood?" How is circulation caused?

15. How many times does the blood in the body pass through the different organs?

16. Describe the heart, telling about its shape, its parts, and its work.

17. What is an artery? A vein? A capillary?

18. What is the systemic circulation? The pulmonary?

19. Why does the blood travel more slowly in the veins than in the arteries?

20. What arrangement has Nature made to prevent the blood in the veins from flowing back into the arteries?

21. Why is all the blood sent to the lungs?

22. Why is some of the blood sent to the liver?

23. What is the lymphatic circulation?

24. What are the lymphatic glands? What is their use in the body? What is the necessity for these glands?

25. What helps the heart to circulate the blood?

26. How frequently does the pulse beat in an average adult (*a*) when he is sitting upright, (*b*) when he is standing, (*c*) when he is walking, (*d*) when he is running rapidly?

27. How is the blood supply controlled so that any organ will get just the amount it needs?

CHAPTER VII

Pure Blood and a Sound Heart

The life of the body depends, as we have seen, upon the blood. The condition of the blood is therefore a matter of the greatest importance. Upon its purity depend not only the nutrition of the body but the power of the body to resist diseases of all kinds. Impure blood is the cause of a large proportion of the diseases from which human beings suffer.

The importance of blood purity

The prompt healing of a cut or wound is evidence of clean, pure blood. When the skin is broken, germs are admitted to the tissues, from which they are ordinarily kept out by the skin. If the tissues are kept in a healthy state by pure and vigorous blood, the few germs that enter are quickly destroyed, and there is no infection; but when the blood is not pure, the cells and the blood are not able to make the active defense necessary. So the germs multiply, *suppuration* (the making of pus) occurs, and the wound may take a long time to heal. It is thus clear that one's blood cells should be kept in good fighting condition, so that they may have power to resist and destroy germs. We owe our protection or recovery from infectious diseases of all sorts largely to the activity of these wonderful little fighters.

It has been said that "all life is under water." The cells of the body are bathed in the lymph which drains out from the blood vessels. If the blood is impure, every cell and fiber of the body is bathed by an impure fluid, and must be more or less injured.

Picture in your mind a glass globe filled with water, with fishes swimming about in it. Imagine that indigo, ink, or some other kind of coloring matter is dropped into the water. All the water will at once become tinged, and, if the coloring matter is poisonous, the fishes will soon show signs of uneasiness; and, unless they are relieved by the water's being changed, they will soon die. This illustrates the condition of the living cells of the body when bathed in impure blood. Every cell is injured by the impurities brought in contact with it.

You see now why, as you have already learned, all substances containing poisons, such as alcoholic drinks, and such drugs as opium and tobacco, injure the blood and lessen its defensive power. When alcohol is taken freely, the blood loses in part its power to carry oxygen. This accounts for the bluish appearance of the face, nose, and lips of an "alcoholic," or one who drinks a good deal of whisky, beer, or the like. Irritating substances such as pepper and mustard, and tea and coffee, which contain caffein, are also injurious to the blood.

Eating too much and especially eating an excess of meat will render the blood impure by filling it with unused materials, which must be treated as waste matter.

Overwork and lack of sleep render the blood impure because the body is not able to get rid of the waste tissue or poisons which form in large quantities when the body is at work. The work of repair in the body is more active during sleep than during waking time. The red cells of the blood which are worn out are then replaced, and thus the red color of the blood is maintained. If one does not sleep well, this repair of the blood does not take place so perfectly.

Neglect to maintain the right activity of the organs that get rid of wastes — the lungs, the kidneys, and the bowels — allows these waste matters to accumulate in the blood, and make it im-

pure. If the lungs are not rendered active by proper exercise, the blood will not get a sufficient amount of oxygen to burn up the wastes, and these will get into the skin and other tissues, and will produce a dull, muddy complexion and other signs of impurity of the blood.

When the colon is not cleared regularly the poisonous matters which are retained are absorbed into the blood and they may become a source of disturbance and injury throughout the body. If a sufficient amount of water is not taken to dilute the blood, wash the tissues, and assist the kidneys in removing the acid poisons which it is their particular duty to separate from the blood, these injurious substances are retained and give rise to headache, gout, and other maladies.

How to purify the blood

The idea that the blood may be purified by drugs of any sort is a great error, which has been the cause of much mischief. There are no herbs nor drugs, the taking of which will purify the blood. Impure blood is purified not by putting something into it but by taking something out of it. Water is the universal cleansing agent, and its free use is necessary for blood purification. It washes the tissues, dilutes the blood, and encourages the kidneys to remove wastes. To undertake to purify the blood by means of pills is about as reasonable as to undertake to cleanse a soiled garment by soiling it more.

Vigorous exercise out of doors is one of the most important means of maintaining blood purity. Why?

An insufficient amount of food very soon makes the blood poor and thin. Of course, the blood must be enriched by an ample supply of pure foods, as well as kept pure by the removal of wastes and the keeping out of unwholesome materials. It is not only important to eat a sufficient amount of food, but it is equally important that the food eaten should contain

the necessary amount of iron. The body loses each day about one fourth of one grain of iron. This amount must be taken in the food daily in order to prevent the gradual loss of iron, which will lead to a lessening of the amount of blood and the production of a poor quality of blood cells.

Iron suitable for the use of the body is found in the green parts of plants; all garden vegetables and greens of all kinds, such as turnip tops, spinach, beet tops, dandelions, and the green leaves of cabbage and lettuce, are rich in iron. Many common weeds also contain iron, particularly purslane, narrow-leaved dock, and redroot, all of which make excellent greens. The yolk of an egg is also rich in iron. Red meats contain iron, but it is in a form which is not so easily assimilated as that in which iron is found in vegetable foods. Bran contains a generous quantity of iron. Iron is likewise found in considerable quantities in strawberries and other berry fruits.

Care should be taken to include in each meal some dish which furnishes iron in abundance. Growing children require twice as much iron as do adults. In general, foods which are rich in lime are also rich in iron. Milk is an exception to this rule, being rich in lime but very poor in iron.

Cold baths increase the number of active cells in the blood. This has been proved by actually counting the number of cells before and after a bath. It must not be supposed that the cells added to the blood are formed in this short time. Cells which have been held idle are by this means brought into active circulation and made useful. If, however, a cold bath is taken regularly from day to day, there is an actual increase in number of blood cells formed. In this way, the cold bath increases the resisting power of the body and rallies the blood cells, so to speak, calling them out from their hiding places and preparing them to fight with vigor the battles that must be waged every

moment in defense of the body. Cold baths also improve the quality of the blood by increasing its alkalinity. The circulation of the blood is quickened and improved by a cold bath. It increases the force of the heart beat, and deepens the breathing, so that an increased amount of oxygen is taken into the lungs for the purification of the blood. But it should be remembered that one must always react favorably to cold baths or they may injure him. That is, he must feel warm and vigorous after them. Most people cannot remain for along period in cold water without becoming chilled and perhaps seriously injured.

Things that affect the heart unfavorably

In order that the blood may perform its work, it is necessary not only that it should be rich in food elements and free from impure substances, but it must also be circulated properly by a strong heart.

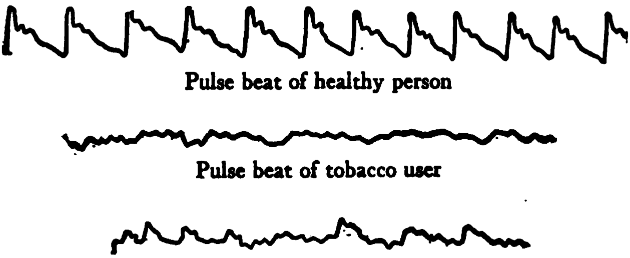
Nature has constructed the heart so that it can adapt itself to all the ordinary needs of life; and if we are careful not to impose needless burdens upon it, nor to illtreat it in any way, we may expect it to do its work well for a long lifetime. If it fails to do this, the cause is usually some fault for which we are ourselves responsible.

Great extremes of heat and cold are injurious to the heart. Heat stimulates it to a high degree, while the effect of cold is to depress and to weaken it and also the small blood vessels. Hence, you see it is of importance to protect the body adequately by adapting the clothing to the seasons and to the needs of daily life. It is especially important to clothe the feet well, so that a proper balance of the circulation may be maintained. Many of the large veins, especially in the extremities, are located near the surface, and hard pressure interferes with the flow of blood through them. For this reason, elastics on the arms or legs, and tight shoes, belts, or collars are injurious.

Very strong emotions affect the heart injuriously. Violent anger has sometimes caused a person to drop dead from sudden heart failure. The lesson to be learned from these facts is that we should keep the emotions and passions well under control. Does this mean we should not be joyful? What does it mean?

The pulse of the tobacco user indicates unmistakably the injury which smoking does to the heart. The heart loses its firm, steady beat and is feeble and irregular. This condition is so well known that it has received the name "tobacco heart."

Alcohol injures the muscles of the heart and the blood vessels, and if its use is kept up it may result in a hardening of the walls



Pulse beat of healthy person

Pulse beat of tobacco user

Pulse beat of drunkard.

TOBACCO AND ALCOHOL AFFECT THE HEART.

of the arteries, which will bring on an early old age. The habitual use of alcohol causes the heart to be overloaded with fat, which interferes with its work. In some cases, its muscular tissue is changed to fat and it loses its strength, so that the heart-beat is a mere flutter. The muscular walls of the small arteries of the brain and other parts are likely to undergo a similar change, and they may become so weak that they are not able to resist the pressure of the blood. Apoplexy (the bursting of a blood vessel in the brain) is more frequent among those who use alcohol than among abstainers.

Alcohol quickens the pulse, not by strengthening the heart, but by affecting the nerve centers that control the heart and the small blood vessels. In consequence, the heart "runs away" as it were, like a steam engine which has lost its "governor" or a clock pendulum from which the weight has been removed. The red face and eyes so often seen in a drunkard are due to a paralysis of the small blood vessels, which keeps them always full of blood.

These things show us that alcohol has an injurious effect upon the heart. Can one afford to take the risk of weakening this wonderful organ in any way? In a severe illness, everything depends upon the ability of the heart to stand the strain of the disease, and if it has been weakened from any cause, it may suddenly fail. It has been found that heavy beer drinkers succumb more readily to disease than abstainers, on account of the weakened condition of the heart, known as "beer drinker's heart."

Many of the headache remedies commonly used are manufactured from coal tar, and these have a very injurious effect on the heart. Medicine of any kind should never be taken except by the advice of a physician. Why?

Lack of elimination of body wastes is a common cause of disease of the blood vessels — perhaps one of the principal causes of hardening of the blood vessels and premature old age.

Severe exercise may injure the heart by placing too great a strain on it. Going to excess in football or bicycle riding, or other severe and long-continued exercise may overwork the heart and cause incurable disease. The heart, like any other muscle, enlarges by exercise. An enlarged condition of the heart known as "athletic heart" may be caused by too severe exercise. In this condition there is trouble frequently with the

valves of the heart, which do not close completely, but allow a leakage of the blood backward. This increases the work of the heart, as some of the blood must be pumped twice.

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VERY HARD AND PROLONGED EFFORT, AS IN BICYCLE-RIDING, ROWING, RACING, AND THE LIKE, ARE LIKELY TO OVERTAX THE HEART, ALTHOUGH THE DANGER WILL BE LESSENED IF ONE TRAINS GRADUALLY FOR GREAT EFFORT.

How to strengthen the heart

The heart is developed and made strong by exercise, just as is any other muscle. The size of the heart is, as a rule, proportioned to the amount of work it habitually has to perform. Animals kept in cages or in captivity have been found upon examination after death to have much smaller hearts than those of other animals of the same species. The heart of a race horse is much larger than that of an ordinary work horse. The heart of a stag, a very active animal, is, in proportion to the size of the animal, about twice as large as that of a pig kept in a pen. Can you tell why?

One who has a well-developed and strong heart has more vigor, more endurance, and more courage than he otherwise would have. When one not accustomed to daily active exercise hurries to catch a train or runs up a flight of stairs, he gets out of breath very easily and perhaps suffers from heavy beating or palpitation of the heart. Enough daily exercise should be taken to keep the heart strong and vigorous, so that it will not be affected by moderate exertion.

The same exercise which strengthens the legs in running, or the arms in rowing, also strengthens the heart by forcing it to do the work necessary to pump the blood to the active muscles, and carry it to the lungs for purification.

One not accustomed to exercise should begin with a little at a

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THE HEART CAN BE TRAINED BY PROPER EXERCISE SO THAT IT WILL BE STRONG AND CAPABLE OF MEETING WITHOUT INJURY THE DEMANDS THAT ARE MADE UPON IT.

time, increasing the amount as the heart becomes stronger. The effect on the pulse beat and the breath will show how much

exercise it is safe to take. Take a short run of about a minute or a trot of a few minutes and notice the effect upon your breathing and your pulse. One should avoid getting very much out of breath and exciting the heart to such a degree as to produce a very rapid pulse. Why? The shortness of breath occasioned by exercise should pass away after a few minutes of rest and the pulse should also return to its ordinary rate. Outdoor games — swimming, rowing, walking, and especially mountain climbing — are excellent forms of exercise for strengthening the heart.

Health Problems

1. Can you tell when you look at a person whether or not his blood is pure? Mention the signs that indicate impurity.

2. Have you ever noticed the eyes and skin of a drunkard? If so, do they seem like the eyes and skin of normal persons? Why is the end of a drunkard's nose redder than it should be?

3. Can a person who works at a desk all day and who does not take exercise in the open air keep his blood from becoming impure? Explain.

4. Should you expect to find pure blood in persons who live all the time in a town or city where the sun is clouded because of smoke and dust? Explain.

5. Many persons think they have to take blood purifiers in the spring. Why should they feel the need of such things especially in the spring? Do you think they can purify their blood by taking such medicines?

6. Do you think it would be wise for a weak person who is not accustomed to cold baths to jump into a tub of very cold water or into a cold river or a cold lake? Explain.

7. I know boys who wear very tight belts to hold up their trousers. Do you think they are likely to be injured in this way? Why?

8. Why are boys who use tobacco or alcohol not allowed to join an athletic team in a high school?

9. Do you know persons who get out of breath if they merely walk rapidly? What is probably the matter with such people?

10. Does one need to take special heart exercises or will the heart take care of itself if one lives right, — that is, if he takes enough food for his

needs, exercises regularly so as to keep his body and muscles in good condition, refrains from putting poisons into his body, and so on?

Review Questions

1. Why should blood cells be kept in good fighting condition?
2. Suppose the blood is impure; what happens to every cell in the body?
3. How do alcoholic drinks, such as whisky and beer, affect the blood?
4. How does eating affect the blood? How does sleep affect it?
5. What will happen to the blood if the body does not get rid of wastes?
6. What organs have to do mainly with getting rid of wastes?
7. Why is water valuable in keeping the blood pure?
8. Can one make the blood pure by taking pills? Why? What is the only way in which one can make his blood pure?
9. Mention all the benefits that come from cold baths, if one is strong enough to take them.
10. Why is it necessary to have a strong heart?
11. Tell how these things affect the heart: tight clothing; strong emotions, as anger or the like; tobacco; alcohol; very violent exercise.
12. Why do people who use a good deal of tobacco and alcohol seem less able to resist diseases than others?
13. How can one strengthen his heart so that it will be ready for any need of daily life?

CHAPTER VIII

THE BREATH OF LIFE

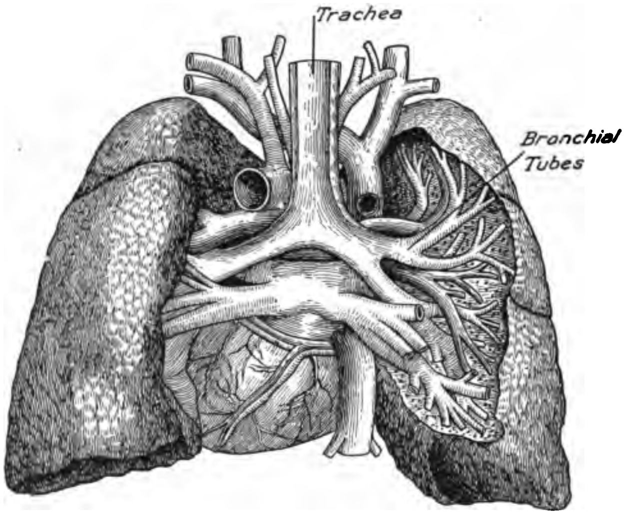
FROM what you have already learned you know that we breathe to obtain the life-giving gas called *oxygen* and to expel the poisonous gas called *carbonic acid* or *carbon dioxide*, which is formed in all living things. Every one of the many millions of tiny living creatures or cells of which the body is made up must breathe in order to live. That is, each cell must get a constant supply of oxygen and must get rid of its carbon dioxide. Oxygen is therefore essential to life. Its great use in the body is to set free or bring into action the energy stored in the body in the form of digested and assimilated food. The body derives its warmth and power to work from the burning of these food substances in the cells. We know that the burning of wood or coal in a stove cannot take place without oxygen. If a stove is made air tight by shutting up all the draughts, the fire will burn low and after a while will go out altogether. Oxygen is just as necessary for the burning of food, the fuel of the body.

Oxygen, the life-giving gas

The cells, packed as they are in the interior of the body, cannot get their oxygen directly from the air, as the amœba can from the water. It must therefore be taken into the body and carried to them. In the division of labor among the cells, the work of taking into the body the supply of oxygen needed by the cells and of expelling the carbon dioxide formed by them is given to the lungs. Just as the digestive organs prepare the food for all the cells, so the lungs supply the oxygen for all the cells.

There must, of course, be some means of communication be-

tween the lungs and the cells, by which the oxygen from the lungs may reach the cells, and the carbon dioxide from the cells may reach the lungs. This is provided for by the circulation of



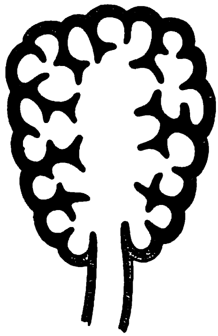
THE OXYGEN NEEDED BY THE BODY IS TAKEN IN THROUGH THE LUNGS, AND CARBON DIOXIDE, WHICH IS INJURIOUS TO THE BODY, IS EXPELLED THROUGH THE LUNGS.

the blood, which is, as we have seen, a carrier between the lungs and the tissues as well as between the digestive organs and the tissues.

The breathing apparatus

The air is admitted to the lungs by means of a tube called the *windpipe* or *trachea*, which at its upper end is widened into a small chamber called the *larynx*, a box made of cartilage in which the *vocal cords* are placed, and which communicates with the air through the nose and mouth. At its lower end, the trachea is divided into two branches, called *bronchial tubes*, one of which passes to the right and one to the left. Each of these is divided and subdi-

vided like the branches of a tree into innumerable smaller tubes or *bronchi*, the very smallest of which are called *bronchioles*. The bronchioles end in small pouches, the sides of which are pitted everywhere with little recesses or tiny sacs called *air cells*. The total number of air cells in the lungs has been estimated to be not less than 1,700,000. The term *cell* is here used in its ordinary sense, meaning a small chamber, and not in the sense in which we used it in previous chapters. What did it mean then?

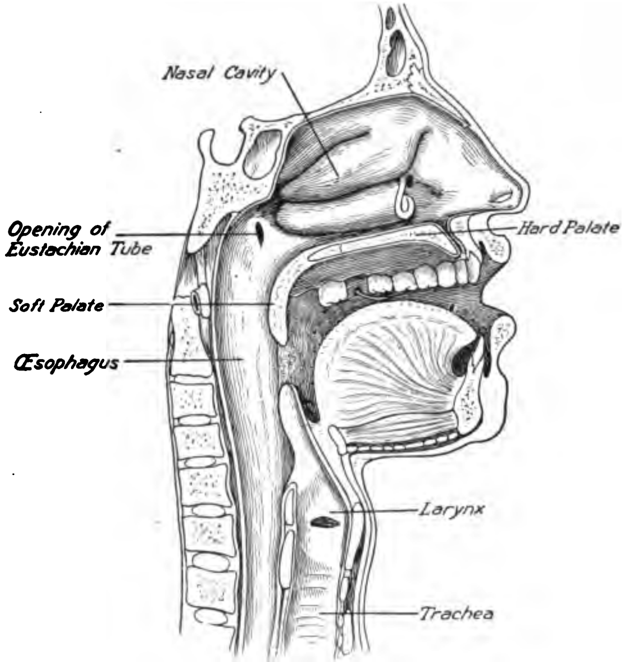


THERE ARE ABOUT 1,700,000 OF THESE AIR CELLS OR AIR SACS IN THE LUNGS. THE OXYGEN IN THE AIR WE BREATHE PASSES THROUGH THE WALLS OF THE CELLS INTO THE BLOOD.

The air cells and air tubes are bound together by means of tissues in which there are a large number of elastic fibers. These enable the lungs to stretch or expand when they are filled with air. The whole is completely inclosed in a membrane called the *pleura*.

The purpose of the lungs is, of course, to bring the blood into contact with the air. The lining membrane of the air cells is of such marvelous thinness that 2500 layers would make but an inch in thickness. On account of the immense number of air cells and minute air tubes, the extent of this membrane is so great that if it were spread out over a flat surface it would cover fully 2000 square feet. Immediately under this delicate membrane, in the walls of the air cells, is a very remarkable network of capillaries, which as you know are minute blood vessels. The blood which passes through this wonderful capillary network is, by reason of the thinness of the lining membrane, exposed to the air in the most thorough manner possible. All the blood in the body passes through the lung capillaries once every minute and a quarter.

The passage which leads to the lungs begins with the mouth and the nostrils. The nostrils lead to the *nasal cavity.* This cavity is divided for about one half its length by means of a partition called the *septum.* The sides of the nasal cavity are

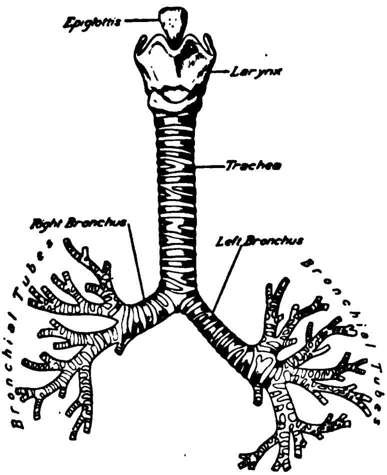


HERE IS SHOWN THE PASSAGE WHICH LEADS TO THE LUNGS. THE ESOPHAGUS LEADS TO THE STOMACH. DO YOU WONDER THAT FOOD SOMETIMES GOES DOWN THE WINDPIPE?

covered with mucous membrane, the extent of which is greatly increased by scroll-like projections of bone and cartilage from the outer walls of the cavity, as you see in the picture. The nasal cavity and the cavity of the mouth unite at their back parts to form the *pharynx*, which is separated from the mouth by a hanging partition, — the *soft palate.* Everything which enters

the lungs or the stomach passes through the pharynx. On either side of the pharynx are the *tonsils*, two remarkable glands which are placed at the entrance to the body to protect it against the germs that are carried in with air and food.

When germs are present in such great numbers that the tonsils are not able to destroy them all, some of the germs penetrate the tissues and the tonsils become infected. The germs creep down into little crypts or pockets, of which the tonsils are full. They sometimes breed there and fill these pockets with germs as a boy may fill his pocket with marbles. Sometimes so many germs cluster upon the tonsils that the tonsils become overwhelmed and lose their power to destroy the germs; the result is that the germs destroy the tonsils. The tonsils then become inflamed and enlarged, and quite frequently their removal is necessary. Infection from diseased tonsils may be carried to the lymph glands of the neck and to the lungs; and enlarged glands, rheumatism, or even tuberculosis may result. Infected tonsils should be removed. One of the best means of protecting the tonsils is by breathing plenty of pure, cold, fresh air. Dust-laden air should be avoided.



AIR CANNOT REACH THE LUNGS EXCEPT BY PASSING THROUGH THE LARYNX, TRACHEA, AND BRONCHIAL TUBES.

Just beyond the root of the tongue, in the front wall of the pharynx, is an opening called the *glottis*, which leads into the larynx, the entrance to the windpipe. The glottis is guarded by a closely fitting covering

called the *epiglottis*, consisting of a leaf-shaped cartilage, one side of which is hinged at the root of the tongue in such a manner that, in the act of swallowing, the cover is tightly closed, preventing the entrance of food or drink into the windpipe. The pharynx itself leads to the *esophagus*, or food pipe.

The whole of the breathing apparatus is lined with mucous membrane, which is kept moist with mucus. Particles of dust and germs which are carried down into the air passages are caught by this mucus, much as flies are caught on a sticky fly paper. Except in the air cells and the pharynx, the walls of the air passages may be shown by the microscope to be covered with minute hairs. By the constant movement of these hairs, or *cilia* as they are called, a stream of mucus is swept upwards towards the mouth, carrying with it the captured dust and germs. In this way the air is cleansed, and dust and germs are in a great measure prevented from reaching the air cells of the lungs.

What takes place in the lungs

If you could watch the blood as it passes through the lung capillaries, you would see a remarkable change taking place in it. The dark purplish hue which it has when it enters the capillaries is changed to a bright crimson before it leaves them and starts for the heart. What is the reason for this wonderful change of color? It means that there has been an actual change in the quality of the blood. A part of its cargo of carbon dioxide has been discharged, and a fresh load of oxygen taken on by the red cells. That is, as the blood flows through the capillaries in the lungs, it gives off carbon dioxide into the air sacs and receives in its place a fresh supply of oxygen.

In the capillaries of the body you would see the opposite kind of change taking place. Here the blood loses its bright crimson color and takes on a darker hue. When the blood reaches the capillaries, the oxygen received from the lungs

is sent through the thin walls of the vessels into the lymph. The cells take up the oxygen from the lymph in which they live (just as the one-celled animal takes its oxygen from the water) and discharge into it their carbon dioxide, which is sent from the lymph into the capillaries. As in the lung capillaries the blood gives up carbon dioxide and takes on oxygen, so in the capillaries of the other tissues the blood gives up oxygen and takes on carbon dioxide; and it is this change which causes it to darken in color. For this reason the blood in the arteries that carry the purified blood *from* the heart is much brighter in color than that in the veins which return the impure blood *to* the heart. It is this dark color of the blood that causes the veins that can be seen through the skin to appear blue.

The change that takes place in the blood in the lung capillaries causes a different sort of change to take place at the same time in the air in the lungs. The process of taking oxygen out and putting carbon dioxide in spoils the air and makes it necessary that it should be constantly renewed.

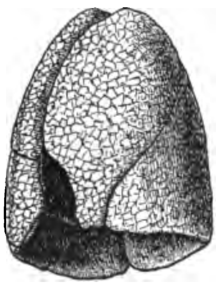
The purpose of breathing is to ventilate the lungs by putting fresh air into them. Do we at each breath expel all the air in the lungs and take in an entire new supply? Most people change only from one tenth to one fifth part of the air in the lungs with each breath.

How the lungs are ventilated

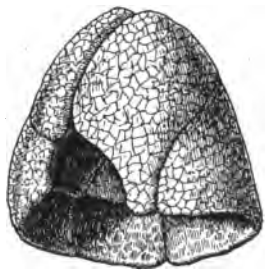
The air is brought into the lungs by a most wonderful pumping device. The lungs, with the heart, are suspended in an air-tight box, — the chest cavity or *thorax*. The ribs with the muscles and other tissues that cover them form the sides of the thorax. The backbone and the chest bone also help to form the walls. The floor or under side of the cavity is formed by a broad strong muscle called the *diaphragm*, which separates the thorax from the *abdomen*, the cavity which contains the stomach, bowels, and other organs.

The diaphragm acts very much like the piston of a pump. It moves up and down, pulling the air into the lungs as it descends.

Air enters the lungs when the chest cavity, or thorax, is enlarged. This is accompanied by a downward movement of the diaphragm and an outward movement, in all directions, of the side walls of the chest. This widening is done by means of muscles which lift the ribs and pull them outward. When these muscles cease their pulling, the chest walls return to their former position, and the air which was drawn into the lungs by the enlarging of the chest is forced out again. The natural elasticity of the lungs and the contraction of the muscles of the abdomen also aid in expelling the air. The lungs act much like a pair of bellows, except that the air passes in and out at the same opening. The windpipe is the nozzle of the bellows, the lungs are the pouch, and the points of the ribs on either side, the two handles. When the muscles contract, the points of the ribs are separated, just as the handles of a pair of bellows are drawn apart. This may easily be seen in the panting of a dog, or in the breathing of a long-distance runner. The diaphragm may be compared to the piston of a pump, since it moves up and down helping to draw air into the lungs as it descends and to force air out as it rises.



WHEN ONE BREATHES OUT, THE LUNGS CONTRACT.

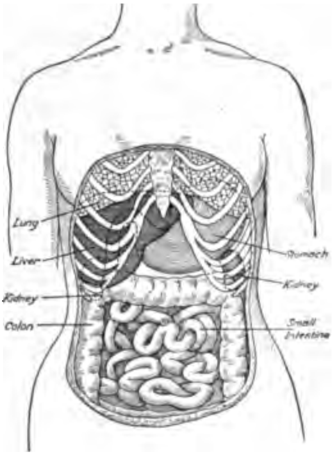


WHEN ONE BREATHES IN, THE LUNGS EXPAND.

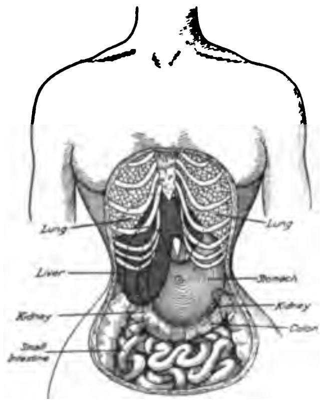
There are, as you can see, two acts in breathing. The first, or drawing in of the breath, is called *inspiration;* the second, or

sending out of the breath, is called *expiration*. As a rule the lungs act once for every four heart beats. See how long you can hold your breath. It is not ordinarily possible to do this for more than half a minute, but if you will first take several deep inspirations, you will find that you can hold the breath longer. Why? The very longest time, however, that the breath can be held even by the most practiced, such as deep sea divers, is three minutes.

In natural breathing, when the movements are not in any



WITH PROPER DRESSING THE LUNGS ARE NOT CROWDED, AND ALL THE VITAL ORGANS HAVE ROOM TO DO THEIR PROPER WORK.



WITH TOO TIGHT CLOTHING THE LUNGS ARE NOT ABLE TO EXPAND PROPERLY, AND ALL THE VITAL ORGANS ARE HANDICAPPED IN THEIR WORK.

How to breathe correctly

way interfered with, there is a movement of the whole trunk, chiefly in the region of the waist. There are two very harmful modes of breathing which must be avoided. One of these is called costal or "rib" breathing. In it the movement is chiefly in the upper part of the chest and the diaphragm does scarcely any work. This manner of breathing

is common among some women, for the reason that they constrict the body with tight garments and so interfere with the movements of the diaphragm and the lower rib muscles. The work of the diaphragm assists the circulation and the digestion as well as the breathing, and anything that interferes with its action is injurious.

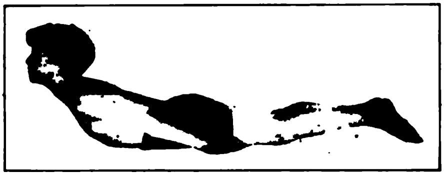
Although women dress much more healthfully now than they did even a few years ago, this manner of breathing is still common among them. It has given rise to the idea that women naturally breathe in a different way from men; that is, only with the upper part of the chest. This idea is shown to be incorrect by the fact that little girls and uncivilized women breathe in exactly the same way that boys and men do; that is, by an expansion of the whole chest, particularly of the lower part.

Another unnatural method of breathing is called "abdominal breathing." It is caused by weakness of the muscles of the abdomen and is most common among men who lead sedentary lives. The weakened muscles yield to the downward pressure of the diaphragm, and the abdomen bulges forward. There is very little movement of the rib muscles. The diaphragm does all the work, and the upper thorax does not expand at all. The proper ventilation of the lungs does not take place, and the abdomen becomes prominent.

Neither costal nor abdominal breathing brings the lungs fully into action. In those parts that remain idle, the air stagnates, and carbon dioxide and other poisons accumulate. The germs of pneumonia and tuberculosis and other disease-producing microbes are likely to find lodgment in these idle parts.

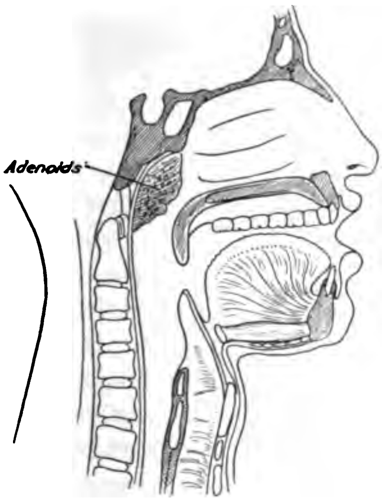
The muscles of the abdomen are of assistance to us in breathing. As the breath is drawn in when the chest is fully expanded, the abdominal muscles are stretched and made tense, because

of the pressure of the diaphragm upon the organs contained in the abdomen. In expiration, these muscles contract, as does rubber released after stretching; and by pushing the abdominal organs upward again, they aid in crowding the air out of the lungs, and in preparing for another incoming breath. In order to serve this useful purpose, the abdominal muscles must, of course, be kept vigorous by exercise.



THE PICTURE SHOWS ONE WAY TO KEEP THE ABDOMINAL MUSCLES IN GOOD CONDITION THROUGH EXERCISE. STRONG ABDOMINAL MUSCLES ASSIST IN BREATHING.

The proper passage for the air into the lungs is through the nostrils, which are especially fitted for purifying and warming it. The nostrils are guarded by hairs which strain out dust, and their mucus also catches dust and germs. The nose not only acts as a strainer, but it also warms the air, moistens it when it is too dry, and warns us when it is impure.



ADENOIDS OBSTRUCT BREATHING AND MAKE ONE UNCOMFORTABLE AND EVEN STUPID. THEY SHOULD ALWAYS BE REMOVED.

Many persons acquire the harmful habit of breathing through the mouth. Mouth breathing in children is usually caused by *adenoids*, a growth of tissue which often nearly fills the breathing passages. You know how uncomfortable, how stuffy and stupid you feel when the nasal passages are obstructed by means of a "cold

in the head." The boy or girl who has adenoids is always in this condition. As a result of the obstruction of the air passages, the whole body suffers from lack of oxygen. The mouth breather can usually be distinguished by his peculiar expression and half-dazed condition. He is inattentive and cannot understand or study well. His eyes are usually dull, his expression stupid, and the open mouth, which is necessary for the passage of air, adds

THIS BOY'S MOUTH BREATHING WAS CAUSED BY ADENOIDS.

THE SAME BOY AFTER THE ADENOIDS WERE REMOVED. IT IS EASY FOR A SURGEON TO REMOVE THEM.

to the unattractiveness of his appearance. Sometimes as a result of mouth breathing the features become distorted, the upper lip becomes shortened, and the upper teeth project. Adenoids are frequently a cause of deafness. A physician should always be consulted when mouth breathing is found to be a habit. The removal of the adenoids is a very simple matter, but their effects if allowed to remain are serious and may affect a person's health for the rest of his life.

"To breathe well is to live well, — to live longer and better."

While the lungs are to some extent under our control, still their action is, like that of the heart, automatic, or self-regulating. During sleep as well as during waking hours, their movements are carried on with rhythmical regularity. The breathing is not so deep during sleep as during activity. It is also slower. Less oxygen is used when the body is asleep, and this results in lessened breathing. The work of the liver and the kidneys and the repairing work of the cells goes on during sleep, and this requires oxygen. Hence the body should be supplied with an abundance of fresh air during sleep by proper ventilation of the sleeping room. The amount of air taken in during sleep may be increased by enlarging the capacity of the lungs by suitable exercise while one is awake. It was found by experiment that the amount of air taken into the lungs during sleep was doubled in students whose breathing capacity had been increased by exercise.

How breathing aids the circulation and digestion

The act of breathing is a blood-pumping process, as well as being the means by which air is moved in and out of the lungs. The enlarging of the thorax, by means of which air is sucked into the lungs, helps at the same time to suck the blood in toward the great veins that lead to the heart. While this is happening, the downward pressure of the diaphragm, which presses the abdominal organs against the muscular walls of the abdomen, serves to force the blood upward. This empties the blood of the veins in the abdominal cavity into the chest, thus helping it on toward the heart. You can see from this that deep breathing aids the circulation of the blood.

The stomach lies just below the diaphragm, which, as it moves up and down, kneads the stomach and its contents and in this way assists the work of mingling the foods and the digestive fluids. In the ordinary breathing of a person who takes little

active exercise, the movements of the chest are slight, and the action of the diaphragm produces small effect; but by moderate exercise the movements are more than doubled, and the stomach is then kneaded in a vigorous manner. In this way moderate exercise after eating is beneficial, though violent exercise should be avoided. Why? Would the practice of taking breathing exercises after meals be helpful to digestion? Why?

Effects of alcohol and tobacco on the lungs

The use of alcohol or tobacco is, as you might expect, injurious to the respiratory passages and the lungs. You know that alcohol greatly weakens the power of the body to resist germs. One who uses alcohol is therefore especially liable to attacks of grippe and pneumonia, as well as to catarrh of the air passages. The smoke of cigarettes contains a poisonous gas called *carbon monoxide*. When this smoke is inhaled, as it frequently is by smokers, both the poisonous gas and the tobacco poison get into the blood in the lung capillaries and are a source of injury to the cells.

Dr. Webb, who examined many thousands of soldiers during the World War, found that practically all smokers show evidence of congestion and irritation of the lungs. The records of the Phipps Institute, of Philadelphia, show that non-smokers suffering from tuberculosis are more likely to recover from the disease than smokers. In some parts of the United States, tuberculosis is increasing among men, while it is decreasing among women. It is quite possible that one reason for this is the rapid increase within the last few years of the smoking habit among men. If the habit of smoking increases among women, the difference just mentioned may grow less.

Nothing is of more importance for a long and vigorous life than large lung capacity. By means of an instrument called the *spirometer*, into which a person breathes after taking a deep

inspiration, it is possible to find out the *vital capacity*, that is, the amount of air change which takes place in the lungs. A person's lung strength can be learned, however, without the use of the spirometer, by testing the ability to endure exercise which taxes breathing power, such as running up and down stairs or other running exercises. Extreme breathlessness caused by moderate exercise indicates either that the heart is weak or that the breathing capacity needs developing.

Developing lung capacity

THE SPIROMETER MEASURES THE CAPACITY OF THE LUNGS. YOU SHOULD TEST YOUR LUNGS AND SEE IF YOU CAN INCREASE YOUR CAPACITY.

Any exercise which compels full, deep breathing is a valuable means of developing the lung capacity. Breathing power depends upon the strength of the muscles that control the chest walls, as well as upon the size of the chest. Exercise in a gymnasium, chopping and sawing wood, digging, laundry work, scrubbing, and all sorts of active housework and farm work are good for developing the chest.

When a chest is not stretched to its fullest capacity many times daily, it is likely to lose its capacity for holding much air, especially after the age of thirty. The proper time for chest development is in childhood and youth. During this period the soundness of the heart makes it possible to take without injury those vigorous exercises

which are necessary to secure the highest degree of lung capacity.

We have seen that the breathing movements are for the purpose of supplying the cells with oxygen. The breathing is therefore regulated according to the needs of the cells. When the large muscles of the body are actively at work, as in running, oxygen is rapidly used up by the working cells, and the blood is filled with carbon dioxide. The heart beats more rapidly to send the impure blood to the lungs for purification and a supply

LIVELY GAMES OF ANY SORT THAT ONE ENJOYS WILL INCREASE THE CAPACITY OF THE LUNGS.

of oxygen. In this way a sort of thirst for air is created and deep and rapid breathing is the result. Exercises of this sort are far superior to so-called "breathing exercises," in which the lungs are forcibly compelled to take in more than the ordinary amount of air, though these latter exercises have some value. The impulse which comes from within, from the so-called "respiratory centers," stimulates the respiratory muscles

so that they cause the chest to execute the strongest breathing movements with the greatest ease, ventilating every portion of the lungs and filling every air cell to the utmost capacity.

Increasing lung capacity

Running, or other active exercise of the leg muscles, is an excellent means of increasing the lung capacity. At first the breathing is slightly difficult, but after a short time, when the runner has his "second wind," respiration becomes easier. The entire lung surface is then brought into action. In ordinary breathing not all the lung surface is used; hence the lungs are likely to become diseased, unless brought into full use by exercises which necessitate deep and full respiration. Runners always have large and active chests, and sedentary persons usually have chests of limited capacity with rigid walls.

One of the best exercises for developing the breathing powers is swimming. The position of the body and the active movements of the arms and legs make swimming a most effective breathing exercise. The contact of the skin with the cold water also stimulates the movements of the chest, while, by increasing the energy of the muscles it encourages vigorous muscular movements. Even the ordinary cold bath is an excellent means of enlarging respiration. It deepens the breathing, and this in time results in greater lung capacity. It also increases the circulation of the blood in the lungs, which means greater absorption of oxygen. The daily cold bath, by increasing the resistance of the body, prevents colds and other more serious diseases of the lungs and respiratory passage. In experiments made with young people, the girth or size of the chest was increased in some cases one and one half inches in a few weeks as a result of swimming exercises.

We need a large amount of air — a pint of air at every breath. If we can take more, all the better. A consumptive often does

not take half this amount. A pint at every breath, sixteen breaths a minute, equals two gallons every minute; that amounts to 120 gallons an hour, almost 3000 gallons a day. Three thousand gallons would be how many barrels? — Nearly 100 barrels of air. But these figures do not indicate the amount of air required to insure the purity of the air we breathe. A pint of air which is breathed out from the lungs affects at least two cubic feet of air, rendering it unfit to breathe. In other words, for every pint of air we use by taking it into our lungs, we spoil, by sending out a pint of impure air, more than a hundred times as much air or, at least ten thousand barrels of air daily. So the actual daily ration of air, that is, the amount of fresh air each person requires, is about forty to fifty thousand cubic feet, or ten to twelve thousand barrels of air.

Special breathing exercises, as well as those muscular movements which create a "thirst for air," are beneficial because they keep the chest flexible and ventilate the lungs. These movements, as was mentioned earlier, also exercise a beneficial effect upon the digestive organs lying below the diaphragm. Every time the diaphragm contracts it gives them a hearty squeeze, so to speak, emptying out the blood contained in them, as one empties a moist sponge by pressure upon it. All exercises which increase the strength of the abdominal muscles are a means of aiding and improving the breathing.

One should make a practice of breathing deeply for a few minutes several times a day. This should of course be done outdoors where the air is pure. A convenient time is on the way to and from school. Simply filling the lungs with air until every part is expanded and then slowly exhaling is very beneficial. Do this several times in succession. When you are tired or feel dull and stupid, try the effect of going outdoors or opening a window and taking a few deep breaths. You will be sur-

prised to see how this will rest and refresh you and quicken the activity of your brain. After being shut up in a close room or in an ill-ventilated hall or church, be sure to ventilate the lungs thoroughly by taking a few deep-breathing exercises in the outdoor air. Weariness, dullness, and nervousness are usually overcome by the increased ventilation of the body secured by deep breathing.

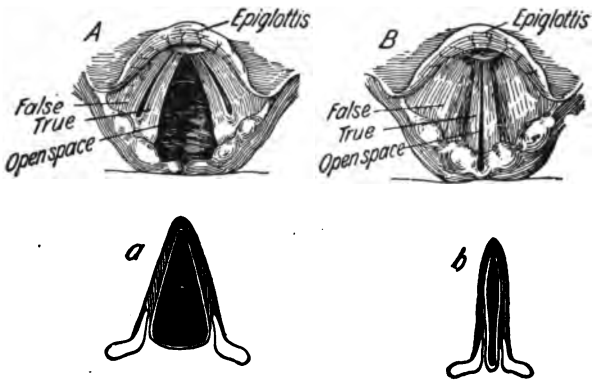
Care should be taken that the breathing movements are in no way interfered with by the clothing. Corsets or tight belts are likely to restrict the action of the rib muscles, and in that way they tie the handles of nature's bellows, the lungs.

The voice

The vocal cords are, as we have seen, situated in the larynx, at the entrance to the windpipe. "Adam's apple" will show you just where the larynx is located. Within the larynx are two bands of tissue which run across the side walls from the front to the back. When these vocal cords are brought together and air is forced through them, sound is produced. Speech is produced by modifying the voice by means of the tongue, teeth, lips, and throat. The pitch of the voice depends upon the weight, length, and tightness of the cords. Change of pitch is brought about by the tightening or loosening of the vocal cords. In a stringed instrument, such as a violin, a heavy string gives a lower tone than a light one. In strings of the same weight, a short string gives a higher tone than a long one, and, in those of the same weight and length, a tight string gives a higher tone than a loose one. In like manner when the vocal cords are long and loosely stretched, the voice is low in pitch. When the cords are short or tightly stretched, the pitch is high.

A grown person has a larger larynx and hence longer vocal cords than a child, and consequently a voice of lower pitch. The change of voice in a boy between the ages of fourteen and

eighteen is due to the enlargement of the larynx, which takes place normally at that period. Do you think the voice should be given severe use while it is changing? A man has a larger larynx than a woman and hence a voice of lower pitch. When



THE LARYNX

A and *a*, the vocal cords in resting position; *B* and *b*, the vocal cords in position for producing voice

men and women are singing together the voices of the men are an octave lower than those of the women.

An important means of preserving the voice is to avoid taking cold. If a cold has been taken, the voice should not be used in singing or loud speaking until the hoarseness is relieved. Permanent injury to the voice sometimes results from disregarding this rule. The use of rich foods and irritating condiments injures the voice by producing a congestion or chronic inflammation of the throat. Smokers are especially liable to disease of the throat because the hot, irritating smoke is brought into contact with the delicate vocal cords.

In speaking, and especially in singing, the muscles of the waist should be used. Increased force as well as greater volume

may be given to the voice by the use of the muscles about the diaphragm, and the voice will then be much less easily fatigued. A high pitched, strained voice should be avoided, as it is irritating to the throat, tiring to the speaker, and disagreeable to the hearer. Those who have not learned the proper use of the muscles in speaking or singing are very likely to use the muscles of the throat and upper part of the chest in a strained injurious way during loud speaking and singing.

Health Problems

1. Tell what happens to a breath of air, from the start until it comes out of the body. Tell the things that it does in the body, and the changes that come to it.

2. Have you ever had a particle of food go down your "windpipe" a little way? Describe your experience when this happened.

3. What arrangement has nature provided so that if food goes the wrong way the body will try to throw it out? Will the body do this without your directing it? Why?

4. Feel your lungs when you are breathing deeply; tell how it is possible for the lungs to expand and to contract. Are there 2000 square feet in the floor of the room in which you are now? Can you imagine the membrane in the lungs as covering 2000 square feet?

5. Why is there so much mucus when you have a "cold"? Why does the nose run freely when one is breathing a good deal of dust?

6. See if you can bring to school some device that acts like a piston. Show the class that air is sucked in when the piston is moved.

7. Explain coughing; how does it differ from breathing? What is a hiccough? What is yawning? What is sighing?

8. See if you can tell with what part of your lungs you habitually breathe. If you try, can you breathe with the entire lung space?

Review Questions

1. What is the purpose of breathing?

2. How do the cells far in the interior of the body get their oxygen?

3. What is meant by "division of labor" among the cell groups in the body?

4. What is the means of communication between the lungs and the cells throughout the body?

5. What is the use of oxygen in the body?

6. Describe the breathing passages, telling about the parts and their uses.

7. What is meant by *air passages?*

8. Where are the tonsils located? What are their uses? What may happen when they become swollen and diseased?

9. Why do people sometimes have tonsils removed?

10. What arrangement has nature provided so that the air we breathe goes to the lungs and the food goes down the esophagus to the stomach?

11. With what are the breathing passages lined? How does this lining assist in keeping good health?

12. What are the cilia, and what do they do to help the body keep in good health?

13. What change in color occurs to the blood as it passes through the lungs? Through the capillaries?

14. Where does the carbon dioxide come from which escapes from the body through the lungs?

15. What is the color of the blood in the arteries? In the veins? Explain.

16. How are the lungs ventilated?

17. Describe the cavity in which the lungs are placed.

18. How does the diaphragm act so as to help one to breathe?

19. What is the meaning of *inspiration?* Of *expiration?*

20. Why is there action of the entire lungs when one breathes correctly?

21. What causes some persons to breathe through the mouth?

22. What is the effect of mouth breathing upon one's health and mind?

23. What should be done for one whose air passages are filled with adenoids? Why?

24. How does breathing assist digestion?

25. Does one breathe as heavily or as rapidly during sleep as when he is awake? Why?

26. What is the effect of alcohol upon the lungs?

27. Why is it desirable to have large lung capacity?

28. Mention ways in which it is possible to enlarge the lung capacity. What is the value of running, swimming, and daily cold bath, in developing lung capacity?

29. Suppose one does not stretch his lungs to their full capacity very frequently, what may happen to them?

30. Where are the vocal cords located? Describe them.

31. What is the difference between the vocal cords of a grown person and those of a child?

32. How is it possible to change the pitch in one's voice?

33. What may happen if one strains the voice while he is hoarse?

34. What muscle should be used especially in speaking and singing?

CHAPTER IX

HOW THE BODY CLEANSES ITSELF

IN any community of people there is a certain amount of waste matter to be disposed of. In a well-regulated city the garbage or waste is daily removed from the houses, and other offensive waste matters are carried away by means of sewers. If wastes are not promptly removed, the health of the people will be in danger.

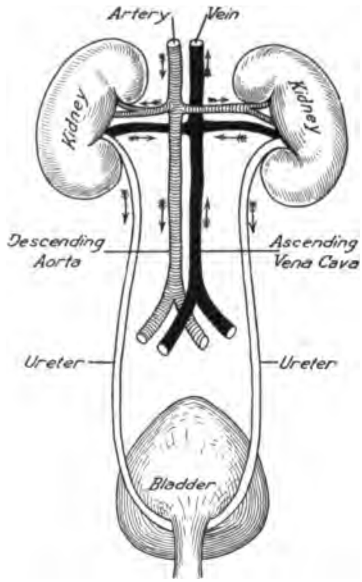
Organs of excretion

We have found that the cells that make up the body community not only take in food and oxygen, but also send out waste matters into the lymph that surrounds them. Of course, the health of the cells depends upon the prompt removal of these wastes. The work of sending them out of the body is called *excretion*, and the cell groups that do the work are called the *organs of excretion* or *of elimination.*

There are four organs by means of which waste and poisonous matters are removed from the body. Two of these we have already considered. They are the intestine, which removes the indigestible and unused residues of the food together with such bile, refuse lime, and iron as the body rejects; and the lungs, which carry off the carbon dioxide. The other two organs are the kidneys and the skin.

When fuel is burned in a stove, the greater part of it passes off up the chimney in the form of gas and smoke, but a small portion remains in the form of ashes. The same thing takes place when food is burned in the body. When fats and carbohydrates are burned in the body, they are changed into gaseous

poison (carbon dioxide) and water. The gaseous poison escapes through the lungs, which are the chimney of the body, and each of the organs of excretion carries off some of the water. Water is constantly being given off from the lungs and the skin. The moisture in the breath may be seen out of doors on a cold day; and when the body is overheated the perspiration becomes visible upon the skin. A certain amount of water is also discharged through the intestine. The kidneys are, however, the chief means of removing any excess water from the blood.



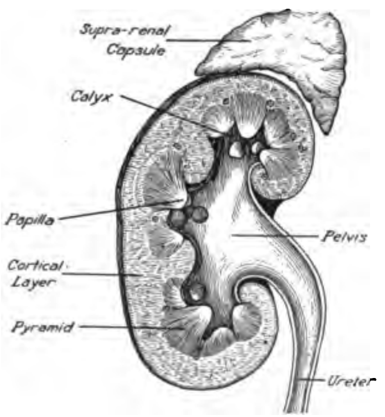
THE KIDNEYS PERFORM A VERY NECESSARY WORK IN REMOVING POISONOUS WASTES FROM THE BODY. IF ONE'S KIDNEYS SHOULD CEASE WORKING, HE COULD NOT LIVE LONG.

The combustion of proteid foods produces, besides carbon dioxide and water, a certain amount of wastes, which correspond to the ashes that would be left behind if the food were burned in a stove. These wastes, after being prepared and made soluble, are extracted from the blood and sent out of the body by the kidneys. A small amount both of the gaseous poison and of other wastes passes out through the skin in the perspiration.

The kidneys, which are very important organs of excretion, are located at the back part of the abdominal cavity, just below the lower ribs. They are placed close to the spinal column, one on each side. Each kidney is a gland shaped like a kidney bean, and weighs from four to six ounces.

Examined under the microscope, the substance of the kidney is found to be made up of very delicate tubes, which begin near the surface of the organ in little round sacs. Each sac contains a minute coiled blood vessel. The tubes leading from the sacs combine as they pass towards the center, becoming larger in size, and finally opening into a cavity in the kidney. This cavity communicates with a long tube which passes to the bladder.

Each kidney contains about 2,000,000 cells. The length of each tubule is about one inch, making an aggregate of more than sixty miles of tubing for both kidneys. Each of these little sacs, or kidney cells, produces during a lifetime of sixty years about two teaspoonfuls of fluid, or one drop every three months. This statement will give something of an idea of the extreme delicacy of the structure of the kidneys and of the necessity for taking the greatest care of these fragile organs. The kidney excretion contains some of the most poisonous waste elements of the body. When from any cause the action of the kidneys ceases, death soon takes place.



THE KIDNEYS ARE CONSTRUCTED IN A VERY DELICATE WAY AND ARE EASILY INJURED. OVEREATING, ESPECIALLY OF PROTEIN FOODS, INCREASES THE WORK OF THE KIDNEYS AND IS LIKELY TO OVERTAX THEM.

The kidneys are always at work, but are more active at some times than at others. Anything that increases the flow of blood through the kidneys stimulates them to greater activity. Drinking water freely is beneficial to the kidneys. Water dissolves the poisons of the tissues and aids the kidneys in removing them.

In summer, especially, when a large amount of water passes off through the skin in the perspiration, it is very necessary to drink a sufficient amount of water to make good the loss from this source.

Habits and foods that injure the kidneys

Overeating, especially of protein foods, the waste products of which it is the business of the kidneys to remove, increases the work of the kidneys, and is likely to overtax them. The kidneys are in close sympathy with the skin. Both remove water and wastes from the blood. Whatever interferes with the work of the one will impose extra labor upon the other. Sedentary habits, neglect of bathing, exposure to severe cold, failure to eliminate waste matters regularly from the colon, the use of alcohol, tobacco, tea, coffee, and patent medicines, and the excessive use of meat may be mentioned as the chief causes of kidney diseases, which are rapidly increasing in our country.

Alcohol injures the kidneys, as it does the liver and all other parts of the body with which it comes in direct contact. It causes inflammations and changes which finally result in the disease and decay of the organs. Disease of the kidneys is very frequent among beer drinkers.

The liver, as we have seen, completes the work of digestion. When it becomes disabled by the use of alcohol or in other ways, some portions of the food are allowed to pass into the general circulation without having been so changed by the liver that they can be used by the cells in building up the body. The removal of these useless substances adds greatly to the work of the kidneys.

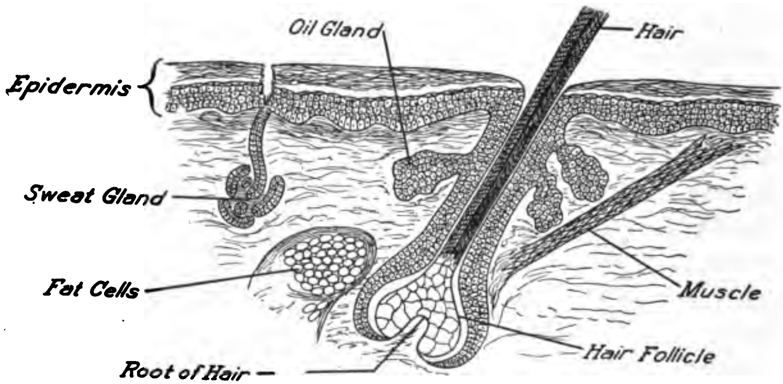
We see, then, what a chain of mischief may be started by the use of alcohol.

Before studying the skin in its work of cleansing the body, we must first mention its other uses and notice how it is constructed.

The chief purposes of the skin are (1) to form a protective covering for the body, in order to prevent the entrance of harmful substances such as germs; (2) to regulate the heat of the body, keeping it at a constant temperature; (3) to receive impressions of heat, cold, pain, and so on; (4) to a small extent, as we have seen, to assist the lungs and the kidneys in the work of excretion.

The work of the skin

You may remember that the outer layer of the skin is called the *epidermis*. This is a covering for the *dermis*, which contains



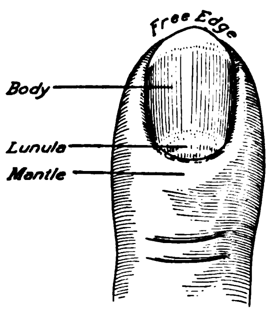
ONE CAN HARDLY BELIEVE THAT HIS SKIN IS SO REMARKABLY CONSTRUCTED AS THIS PICTURE INDICATES.

the active parts of the skin, — the glands, nerves, and blood vessels, — by means of which the various kinds of work of the skin are carried on.

The flattened cells which compose the outer layers of the epidermis are all the time drying and scaling off, and for that reason the skin needs to be constantly renewed by the making of new cells. We have learned that cells multiply by each cell's dividing into two new cells. The cells in the lower layers of the epidermis divide in this way and form new cells to take the place of those that have been thrown off.

Since the epidermis has for its purpose the protection of the delicate parts beneath, it is thickest in those regions of the body where there is the most pressure. On the soles of the feet and the palms of the hands there may be as many as one hundred layers of epidermal cells, while on other parts of the body there are not more than twenty. Constant pressure upon any part of the skin causes a great increase in the number of epidermal cells at that point. A corn on the foot is due to the thickening of the epidermis resulting from the pressure of the shoe.

The hair and nails are curious horny structures which grow out from the skin. Hairs are found upon all parts of the body, with the exception of the palms of the hands and the soles of the feet. Each hair grows from a small, deep pocket in the skin, called the *hair follicle*. Both nails and hair are constantly being formed in the dermis and pushed upward. The uses of the hair seem to be to protect the parts beneath from changes of temperature, as in the case of the head, and to protect sensitive parts from dust and other harmful substances, as in the eyelashes and eyebrows, and the hairs of the nostrils.



THE FINGER NAIL GROWS FROM A LITTLE FOLD IN THE SKIN AND FROM THE TISSUES OVER WHICH IT LIES.

Opening into each hair follicle are one or more *sebaceous glands* which pour out an oily substance to moisten the hair, and to lubricate the skin and thus protect it from drying and chapping. The color of the hair is due to pigmented cells like those which give the skin its color.

The nails grow from little folds in the skin and from the tissues over which they lie. They protect the ends of the fingers and toes, increase the delicacy of the sense of touch, and aid the fingers in picking up small objects.

The inner layer of the skin, the true skin or dermis, contains many blood vessels, glands, and nerves, and also minute muscles connected with the hairs. When one is chilly these muscles sometimes contract, causing a rough appearance of the skin commonly called "goose flesh."

The outer surface of the true skin is not flat, but is thrown up into moundlike projections called *papillæ*, which project up into the epidermis. Some of the papillæ contain blood vessels and nerve endings. The large number of blood vessels with which it is provided give the skin such vitality that small wounds in it will heal very rapidly, if the blood is healthy. Even when quite a large surface of the skin is removed, new skin will grow out from the edges until the gap is entirely covered.

Since it is the protective covering of the body, it is very important that the skin should be kept from injury. Even a slight scratch may open up a way for a deadly germ, which may cause serious and even fatal results. Wounds in the skin should be cleansed with a disinfecting fluid and kept covered.

The work of the sweat glands, of which there are in the skin not less than two and one half millions, is to cool the body by pouring out water upon the skin. This they are doing constantly, but the amount of water is usually too small to be noticeable. When it evaporates before it becomes visible, it is called *insensible perspiration.* The amount of insensible perspiration produced daily by the entire skin is usually from one and one half to four pints. It is by the evaporation of the perspiration that the body is cooled. Exercise or heat greatly increases the amount of perspiration, so that it becomes visible upon the skin and is known as *sensible perspiration.*

Perspiration is not simply a heat-regulating secretion. It is a means by which some of the waste matters contained in the blood are carried out of the body. When the water evaporates

from the surface of the body, the waste matter it contained remains on the skin and becomes mixed with oil from the sebaceous glands, with dead epidermis, and with dust from the air and the clothing. If this waste is not regularly removed by bathing and friction of the skin, it will form a thin coating all over the body, and will give off a bad odor and interfere with the work of the skin. Where there is dirt, there are germs. An unclean condition of the skin encourages the growth of germs upon it, and some of them may get down into the hair follicles and the sebaceous glands, and cause pimples and other skin eruptions.

Health Problems

1. Suppose any group of persons in your community who remove wastes, such as garbage men, should cease to do their work, what would happen? Have you ever known of such a case?

2. Show that the burning of food in the body leaves something like the ashes left from the burning of wood in a stove. Suppose the ashes in a stove or a furnace should not be removed at all. What would happen, in time, to the fire? Is it the same in the body if wastes are not removed?

3. Do you know whether persons who eat a great deal of meat and live a sedentary life are inclined to be troubled with kidney diseases? Ask your physician this question. If he tells you that such persons are likely to have kidney diseases, ask him why and remember what he says.

4. Suppose a person who lives indoors should eat three meals a day composed largely of beans, cheese, lean meat, milk, and eggs. Should you expect such a person to be well? Explain.

5. Suppose the liver and the kidneys could speak when a man was about to take a glass of whisky, what do you think they would say, and why?

6. Suppose you should cover the surface of your body with wax, what do you think would happen? Would the case be about the same if you should let the body become covered with the wastes thrown out by the skin?

7. Why does a part of the outer skin of the feet rub off so easily after a hot foot bath? Why is there so much of this skin on the feet?

8. Show in some way that the sebaceous glands contain an oil which they pour out to keep the skin from becoming hard and dry.

9. Try to find out why people who live in countries where there is a great deal of sunshine have black hair, while those who live in countries where there is not so much sunshine have lighter-colored hair.

10. Think of some way to show that there is invisible perspiration pouring out from the skin all the time.

Review Questions

1. What name is given to the work of sending wastes out of the body? To the organs which have charge of getting rid of wastes?

2. What waste products are formed by the burning of food in the body?

3. How is the gaseous poison, carbon dioxide, removed from the body?

4. What waste is expelled from the body through the skin? What through the kidneys?

5. Where are the kidneys located? What is their shape?

6. Describe what one sees when he looks at the structure of the kidneys through a microscope.

7. What happens when the kidneys cease to do their work?

8. Why is it desirable to drink plenty of pure water?

9. Suppose the skin refused to do its work, what would be the effect on the kidneys? Why?

10. What effect do the following practices have upon the kidneys: over-eating (especially of protein foods); neglect of bathing; sedentary habits; the using of alcohol?

11. When the food is not digested properly, do the kidneys suffer? Why?

12. Name the four chief purposes of the skin.

13. What is the outer layer of skin called, and what is its use? What is the inner layer of skin called, and what is its use?

14. What happens to the epidermis if the shoes rub it?

15. What is the connection between the hair and the nails and the epidermis? What is the name of the pockets in the skin from which the hair grows?

16. What is the use of the sebaceous glands?

17. What are the papillæ? What is their function?

18. Why is it necessary to be careful not to injure the skin?

19. How should wounds in the skin be cared for?

20. What is the work of the sweat glands?

21. What is the meaning of *insensible perspiration?* Of *sensible perspiration?*

22. When perspiration evaporates from the surface of the skin, what does it leave behind?

23. Why is it necessary to bathe frequently?

CHAPTER X

How the Temperature of the Body is Regulated

WHETHER we are shivering with cold in the winter or perspiring in the warmest weather, a physician's thermometer placed in the mouth will generally show that the temperature of the body inside is nearly the same. The ability to maintain a certain temperature under all the different conditions of life is one of the most remarkable of the powers of the human body. The internal temperature of the body is constantly maintained at about 98.6 degrees. At all seasons and in all countries the variation in temperature of a healthy person is scarcely more than one degree. This fact seems wonderful when we consider how greatly the temperature of the air may vary at different seasons and in different countries, — from 70 degrees below zero in Arctic regions to 130 degrees above in the sultry deserts of northern Africa.

The temperature of the body

Things without life, such as a stone or a piece of earth, usually take on the temperature of the surrounding air. Many living creatures do the same thing. The temperature of a frog, a snake, a turtle, or an earthworm differs little from that of its surroundings.

The only creatures which have this great power of maintaining a constant temperature in spite of changes in the surrounding air are mammals and birds. These animals are called *warm-blooded*, because they are usually warmer than surrounding objects; and animals that have not this power are called

cold-blooded, because they usually feel colder to the touch than do warm-blooded animals.

The heat of the body is produced by a slow combustion of food, and this is taking place all the time. This combustion goes on chiefly in the muscles and is much more active during exercise than when the body is at rest. Yet the internal temperature of the body during rest and moderate exercise is the same, although much more heat is produced during exercise. The loss of heat from the body takes place chiefly at the surface, through the skin. A great deal more heat is lost from the body when the surrounding air is cold, yet the body temperature remains the same. By what means is the body temperature so perfectly regulated that it remains the same under all these different conditions?

IF A ROOM BECOMES TOO WARM, ONE OPENS A WINDOW TO PERMIT SOME OF THE HEAT TO ESCAPE. MUCH THE SAME THING OCCURS WHEN TOO MUCH HEAT IS GENERATED IN THE BODY, — THE SKIN PERMITS SOME OF IT TO ESCAPE.

How the body temperature is regulated

Think of two ways in which you may regulate the temperature of a room. If the room becomes too warm, you open a window or door to let some of the heat escape. If the room is too cold, you stir the fire, put on more fuel, or open the stove or furnace draughts so that more heat will be produced. You may control the temperature of a room by regulating the amount of heat that is produced or by regulating the amount of heat that escapes. The temperature of the body is regulated in the same way.

The marvelous work of regulating the temperature of the body is done, not by one organ alone, but by several working

together under the direction of the nerves. The nervous system is the real regulator of the body temperature, but the work is done by means of three organs: the muscles, the blood vessels, and the sweat glands.

The process of heat-making, which is carried on in the muscles, is regulated by certain nerve centers in the brain and spinal cord, which are connected with the muscles by nerves, so that the making of heat is under constant and perfect control. When the body is exposed to cold air or water or is in any way cooled so that the temperature of the blood is lowered, nerve centers in the brain incite increased activity in the heat-making organs and more fuel is burned in the cells. In this way the heat-making process is adjusted to the needs of the body.

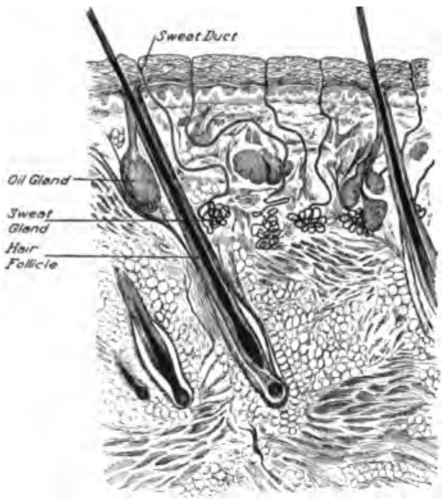
When the cooling of the body is continued to such a point as to produce a considerable fall in the temperature of the blood, one usually feels chilly and begins to shiver. "Shivering" consists in a rapid contraction of the muscles, in which nearly all the muscles of the body take part. As muscular action is always accompanied by the making of heat, this contraction is an automatic method of warming the body. Thus, shivering is simply a natural method by which the body is exercised in order to increase the amount of heat production.

The loss of heat from the body is chiefly at the surface, and the device for controlling this loss is in the skin. There are two ways in which the skin controls the escape of heat from the body. One is by regulating the amount of blood that comes into the skin. The blood carries the heat from the warm interior of the body to the surface, where it escapes. The temperature of the skin is always much lower than the internal temperature and seldom rises above 92 or 93 degrees. After cooling, the blood flows back to the interior of the body. In this way the blood equalizes the body temperature.

When the body is exposed to cold, the blood vessels of the skin contract and shut out the blood, allowing only a small quantity to pass through. The blood is thus kept in the warm interior of the body. When the blood becomes too hot, the blood vessels of the skin dilate and allow a large amount of blood to pass out into the skin where it becomes cooled. This is the cause of the flushing of the face and sometimes even of the whole body, when it is exposed to a warm atmosphere.

Regulation by the skin, the sweat glands, the breath

Through these changes in the circulation of the blood in the skin, the heat loss may be increased to three or four times the usual amount or lessened to the same extent.



THE TEMPERATURE OF THE BODY IS REGULATED TO A CONSIDERABLE EXTENT BY THE PERSPIRATION, WHICH IS CONTROLLED BY THE SWEAT GLANDS. YOU CAN SEE IN THE PICTURE HOW THICKLY THE SWEAT GLANDS, WITH THEIR DUCTS LEADING TO THE SURFACE, ARE DISTRIBUTED THROUGHOUT THE SKIN.

The other method by which the skin regulates the loss of heat is by the work of the sweat glands. We have already learned that the body is cooled by the evaporation of perspiration. Now evaporation cannot take place without heat. A liquid in evaporating must take up heat from surrounding objects. You may easily demonstrate this by wetting one of your hands and then holding both hands in a current of dry air. Why does the wet hand become so much cooler than the dry one? You may make the same experiment

by wetting one finger and noticing how much cooler it becomes than the rest of the hand. If alcohol or ether is used, the cooling process will be much more marked, since both of these evaporate much more quickly than water. In the evaporation of a pound of water, about 1000 heat units are absorbed; that is, as much heat is consumed in the evaporation of a pound of water as would be required to raise half a ton of water one degree in temperature. Approximately two and one half pounds of water are evaporated from the skin daily, representing a loss of about 2500 heat units, or one fourth of the amount of heat generated in the body. The loss of heat may be greatly increased by energetic exercise or by exposure of the body to cool air.

The wonderful power of the sweat glands to protect the body from injury by excessive heat has been shown by experiments in which men remained for some time in a room heated to 260 degrees or to 48 degrees above the boiling point. Meat was being cooked by the heated air of the room, an egg was roasted hard in twenty minutes, and water soon boiled; but the men, although very uncomfortable, remained uninjured. The two million little sweat glands of the skin were hard at work all the time to protect them. The evaporation of the water which the sweat glands poured out upon the skin in great quantities cooled the skin and prevented it from becoming cooked, as it otherwise would have been.

In order that the evaporation of the sweat may take place freely, the air must be dry. In moist air, when there is little or no evaporation of sweat, the cooling of the body is lessened. For this reason, one is much more liable to suffer from heat in a moist atmosphere, on a "muggy" day, for instance, than in a dry atmosphere.

A small amount of heat escapes from the body in the breath

through the evaporation of moisture from the lungs and air passages. Dogs do not sweat, and that is why a dog pants when overheated from exercise or warm atmosphere. By the act of panting, the air is rapidly passed in and out of the lungs, and the increased evaporation cools the dog's blood.

So constant must be the body temperature in health that any variation from the normal, 98.6 degrees, gives cause for anxiety. As a result of shock or of a greatly enfeebled physical condition, the temperature may fall below normal, through insufficient heat production or too great an escape of heat. More often there is a rise of temperature above the normal, and then one is said to have a fever. In fevers, heat production and loss are not so perfectly controlled as in health, because the heat centers are disturbed by the poisons circulating in the blood. The sweat glands are not so active as usual, and the surplus heat does not escape.

Artificial regulation of temperature

When one has a fever, the temperature may be reduced by sponging the body with water, the evaporation of which will carry off some of the surplus heat. A hot bath may be given or a hot pack applied, in order to excite the activity of the sweat glands. It is most important of all that water should be freely drunk at such a time. A person who has a fever should drink a glassful of water every half hour. A little fruit juice of any sort may be added to the water to make it more palatable.

The heat-regulating functions of the body are not under the control of the will. One cannot start or check the perspiration or cause the surface blood vessels to contract or dilate by an effort of will. We may, however, now that we know how heat is produced in the body and how it escapes, do various things to increase or lessen heat production or heat loss.

By active exercise, for instance, we can greatly increase the

amount of heat produced. One exposed to the cold does not usually stand still. He walks or runs about, stamps his feet, claps his hands, swings his arms, and engages in all sorts of muscular activities that increase heat production. In very warm weather, one is, on the other hand, much less active. In the warm countries, the hottest part of the day is usually passed in sleep, reducing as much as possible the amount of heat production.

Active exercise

Heat production is also determined by the quantity and quality of the food eaten. In the Arctic regions, men live largely on fat, which has the highest heat value of any food, while men of the tropics live largely on rice and fruits, which have a low heat value. A larger quantity of food is required in winter than in summer, especially by one actively exercising out of doors. Why?

The escape of heat from the body in cold climates is greatly lessened by the custom of living in heated houses. Some animals burrow into the ground and make themselves nests in which to pass the winter. No animal but man, however, provides itself with artificial heat. This practice has many advantages, but it also has some disadvantages. What are they?

Living in heated homes

Do you think there is any danger from overheated rooms? Have you noticed that one is very likely to take cold in passing from a hot room into the cold outdoor air? Explain. Overheated rooms also have a weakening effect upon the body. The skin becomes relaxed, and the body unduly sensitive to cold.

Cold rooms, or rooms insufficiently heated, may also have injurious effects, because, in them, too much heat may be lost from the body. When the body is chilled and the surface blood vessels contract, the blood is forced back upon the organs within and these are likely to become *congested;* that is, overcharged with blood.

The proper room temperature is 68 degrees. The circulation of the blood will then be well balanced. There will not be an excess of blood in the skin or in the internal organs, but the blood will be properly distributed among them.

When the skin is heated from exercise or a hot atmosphere, the blood vessels it contains become filled with the blood that is forced into them. If a person in this condition, covered with perspiration, sits in a draught or in a cool place, the blood vessels in the skin will contract and the blood will be forced inward. Some part of the lining membrane of the body, usually the nose, throat, or lungs, will, perhaps, become congested with blood, and a cold will be the result. The white cells in the congested blood vessels will lose their vigor and become inactive, and the microbes may gain the advantage and make mischief. For this reason, a person who has a cold is likely to take other diseases to which he may be exposed.

Colds, their cause and cure

The best thing to do when a cold is developing is to increase the activity of the skin as much as possible. This may be done in several ways: (1) by vigorous exercise which will bring every sweat gland into activity; (2) by a hot foot bath or a full bath, which will expand the surface vessels and bring the blood to the skin; (3) by drinking freely of hot water or hot lemonade, which will aid in starting perspiration.

When the blood is drawn to the surface of the body, the delicate internal organs are relieved of the superfluous blood that causes the congested condition.

After the hot bath, a short cold shower or a quick cold rub should be taken; or, instead of either of these methods, a pailful of cool water may be poured over the body. This cooling process stimulates the nerves of the skin and prevents the taking of cold afterwards. It also stirs the white blood cells to

greater activity and so assists in the work of recovering the health.

Human beings living in cold countries have learned that the escape of heat from the body may be lessened by wearing clothing. The natural clothing of the body is the skin and hair. This is true of man as well as of other animals. Savage tribes that live in the mild climate to which man is naturally adapted find little or no clothing necessary for either comfort or health.

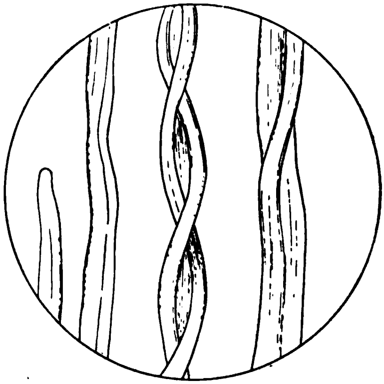
Clothing lessens the loss of heat

But experiments have shown that it is not possible for the body to maintain its temperature if exposed without clothing to air at a temperature lower than 86 degrees. The temperature in which an individual actually lives is that of the air next to the body, inside of the clothing. Clothes lessen the loss of heat from the body by keeping it in a jacket of still air, which is an exceedingly bad conductor of heat. Each additional garment makes another "air jacket." For this reason, several thin garments are much warmer than one thick one, just as a house with double walls and windows, inclosing a layer of air, is warmer than one with single walls and windows, though they may be of double thickness. When one throws off a garment he at the same time removes one of his "air jackets."

Sufficient clothing should be worn to maintain the temperature of the air in contact with the body at from 80 to 86 degrees. This requires for the ordinary man about six to eight pounds of clothing in the summer, and twice as much in the winter season if he is exposed to outdoor temperature. Those who live indoors in heated rooms require, while they remain indoors, very little more clothing in winter than in summer.

Animals regulate their skin clothing to suit the season, growing a thick cover for protection in the winter season and shedding part of this hair in the spring.

A matter of the highest importance is to arrange the clothing on the body so that there will not be too much heat in some parts, while other parts are not sufficiently protected. The arms, legs, and the feet in particular, require special protection, because they are farthest from the heat centers, and because they present a larger surface for heat loss in proportion to their weight and the amount of blood supplied to them than does the trunk. Many persons suffer greatly and are made sick from insufficient clothing of the limbs in the cold seasons, without being aware of the cause of their illness. When the arms and legs are chilled, the blood vessels contract; and, as a consequence, some internal part gets more than its share of blood. Congestion of the head and various troubles with the internal organs may result from this source.



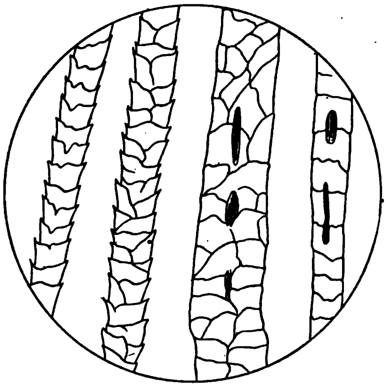
COTTON HAS A FLAT AND TWISTED FIBER.

Effect of material on body's temperature

The material of which clothing is made has a very important relation to health, because different fabrics affect very differently the escape of heat from the body, the absorption of moisture, and the circulation of air about the body. Linen absorbs moisture more rapidly than does wool and dries more quickly. This is true of cotton to a lesser degree and to a still less degree of silk.

Cotton has a flat and twisted fiber that can be manufactured into a much more elastic cloth than can linen, the fibers of which are cylindrical, straight, and stiff. Wool fiber has a jagged, scalelike surface, and is so soft and elastic that it is difficult

to produce from it a compact thread; when woven the cloth furnishes a great number of air spaces between the meshes. Clothing made from wool is both very warm and very light. Woolen garments, however, are likely to shrink and thicken when washed, unless very carefully laundered. In that case, the air spaces between the meshes and the elasticity of the fabric are diminished, until it sometimes happens that woolen undergarments and hose after frequent washings become almost air tight, which is not good for the body.



WOOL FIBER HAS A JAGGED, SCALE-LIKE SURFACE. WHEN WOVEN INTO CLOTH THERE ARE A GREAT MANY AIR SPACES BETWEEN THE MESHES.

As the skin is constantly throwing off moisture, it is very important that the clothing should be able to take it up and pass it out to the air. Woolen fabrics hold moisture for a long time. Wool is on this account not well adapted for garments to be worn next to the skin. Cotton is superior to all other fabrics for this purpose. Linen stands next in value. The fact that the quick drying of linen or cotton exposes the skin to rapid cooling by evaporation necessitates the wearing of outer garments of wool to prevent the too rapid loss of heat during those seasons of the year when extra warmth is required.

The wearing of cotton next to the body is conducive to cleanliness. Cotton undergarments prevent the skin from becoming overheated and from accumulating undue moisture which would relax the skin and keep in a moist and decomposing state the waste matters thrown off by it. Cotton may be

worn at all seasons of the year. It is only necessary to provide sufficient outer clothing to secure the necessary warmth. An additional thick union suit will afford better protection than extra outer wraps.

Health Problems

1. See if you can secure a physician's thermometer to find out your internal temperature. The physician will tell you to put the thermometer under your tongue. Why would it not do to put it on the surface of your body?

2. Note your temperature on a hot day and on a cooler day to see whether it varies according to the weather. Explain.

3. Explain why people who live in cold countries are often large and ruddy.

4. Think of some method which has not been mentioned in your lesson by which you can show to the class that the evaporation of moisture is a cooling process.

5. Explain, as clearly as you can, the process of raising a half ton of water one degree in temperature.

6. Is it a good thing to have very dry air in winter when one wants to keep warm? Is it well to have moist air in summer when one wants to keep cool?

7. Why does one feel cooler where there is a wind than he does where it is quiet, even though there is no difference in the temperature?

8. Why are the people in northern countries usually more active than those in the tropics?

9. Have you noticed that you are often cooler on a hot day when you play or work than when you lie around in the house? Explain.

10. Show why storm windows help to keep a house warm, even when there is no wind.

11. Suppose you could have an undergarment woven so that you could not see through it, and could have another which was porous, and they were both of the same weight, which would you choose? Why?

12. Try this experiment: soak a piece of wool, a piece of cotton, and a piece of silk in water until they are thoroughly wet, then take them out and see which one will become dry most rapidly. Explain.

Review Questions

1. What would happen to the body if the internal temperature should change very much?

2. How is the warmth of the body kept up?

3. Where are the heat-making processes in the body chiefly carried on? How is the production of heat in the body regulated?

4. How does the body protect itself from undue heat or cold?

5. Tell particularly about the work of the sweat glands in regulating the loss of heat.

6. Describe the experiment made by the men who stayed in a room heated to 260 degrees.

7. In what sort of air does perspiration evaporate freely? Why does one usually feel uncomfortable on a muggy day?

8. Why does the temperature of the body become higher when there is a fever?

9. What is a good way to reduce the temperature of the body when there is a fever?

10. What is the influence of exercise upon the making of heat in the body?

11. Why does one usually feel like being inactive on a very hot day?

12. How does the kind of food one eats affect the making of heat in his body?

13. Why is one likely to take cold if he lives in a house that is overheated?

14. Why should one always follow a hot bath with a cold spray or a dash of cold water?

15. How does clothing check the loss of heat?

16. Why is it better to wear several light garments in winter than one very thick and heavy one?

17. What parts of the body should be clothed particularly well in winter, and why?

18. What kind of clothing should be avoided? Why?

CHAPTER XI

THE FRAMEWORK OF THE BODY

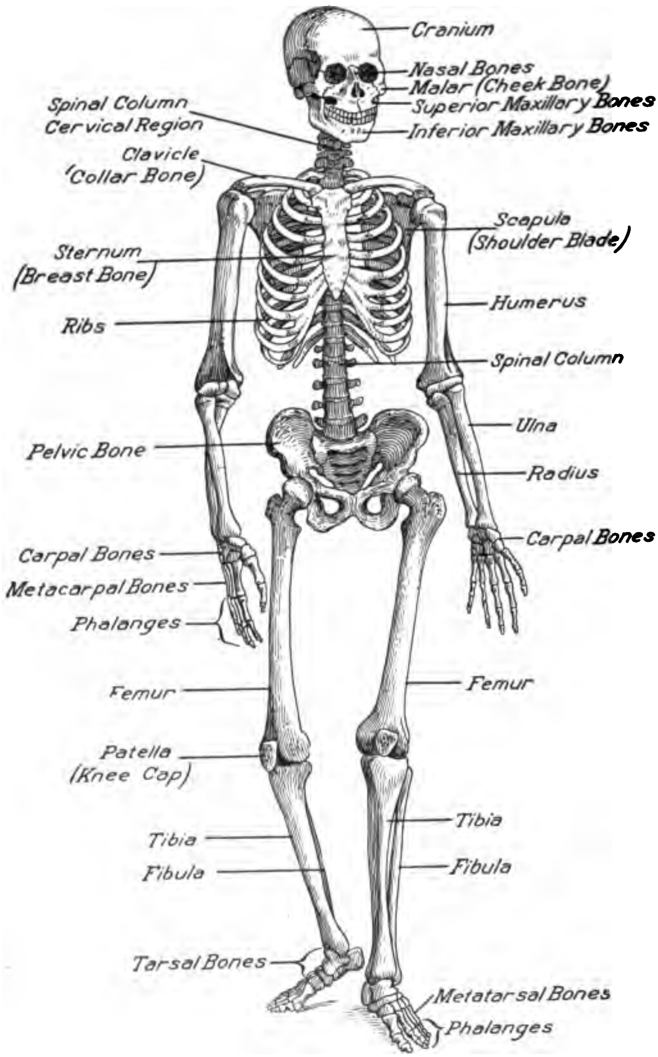
SOME of the work of the body — that of supporting itself — is too heavy for the soft cells to do alone. They therefore build up around themselves solid structures, in much the same way that a snail or a turtle builds its shell out of its own body. Bone and cartilage, which make the solid frame work of the body, are formed in this way.

The nature and uses of bones

The skeleton of a new-born baby is composed almost wholly of cartilage, which, as you know, is not so hard as bone. Cartilage is pliable and for that reason the bones of a little child may be easily bent.

The bones as they grow are gradually hardened through the building of lime into them by the bone cells. By the time they are full grown only a thin layer of cartilage on the ends of the bones remains. In order that they may be properly developed, the food, especially of young children, should contain a sufficient quantity of lime. Milk and whole-wheat bread are good bone-building foods. Why?

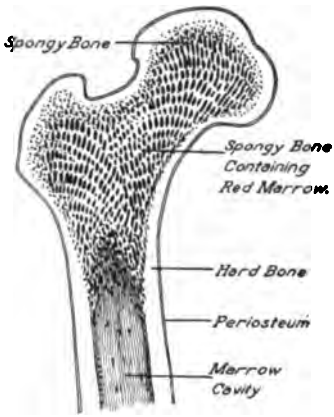
If the lime or mineral matter is dissolved out of a fresh bone by acid, the animal part that remains will be found so flexible that the bone, if long and slender, may be easily tied in a knot. The more lime there is in bones, the less pliable and the more brittle they become. The proportion of lime in the bones seems to increase from year to year through life. For this reason the bones of aged persons are very easily broken.



SEE IF YOU CAN TELL HOW EACH BONE IN THE SKELETON IS USED IN A PERSON'S DAILY WORK OR PLAY.

Bones are covered by a tough membrane called the ***periosteum***, which contains a few nerves, and numerous blood vessels through which the bone is nourished and developed.

If the large bones of the human body were solid, they would be very much heavier without being much stronger. Of course it is necessary that they should be not only firm and strong but light enough to be easily moved. If you look at the picture of a half section of a long bone, you will see that it is only the outer layer that is composed of solid bone. Of what is the inner layer composed? You should note especially that in the center there is a canal or hollow space.



THIS PICTURE SHOWS HOW THE INTERIOR OF A LONG BONE IS CONSTRUCTED. IS THERE ANY ADVANTAGE IN HAVING THE INTERIOR SPONGY?

Do you see that cavities in the bones not only give lightness, but that they also increase the strength of the bones? Can you explain why?

An experiment with a sheet of paper and a book will show that when the paper is rolled into a hollow cylinder, it will support more weight than in any other form. Mention, in addition to bone, other instances in which nature makes use of this plan to secure a combination of lightness and strength. Think of some ways in which man makes use of it also.

You will be interested to learn that the blood is largely formed in the bones. The cavities of the long bones are filled with a substance called *marrow*, containing nerves and blood vessels and large quantities of fat. The fat gives it a yellow color. In the smaller cavities of the spongy bone the marrow contains less fat

and is of a red color. The red blood corpuscles are produced in the red marrow of the bones, while the white corpuscles are formed to some extent in the marrow which fills the hollow spaces of the long bones.

Without a skeleton, the body would not be able to hold itself upright. One of the chief uses of the bones is, therefore, to support the body.

It is easy to see, is it not, that without the bones the various movements of the different parts of the body, as in walking, raising the arms, and so on, would not be possible? The bones aid in moving the body and its various parts. Each bone has roughened places and ridges to which muscles are attached, and the bones thus provide levers by means of which the muscles are able to move the body.

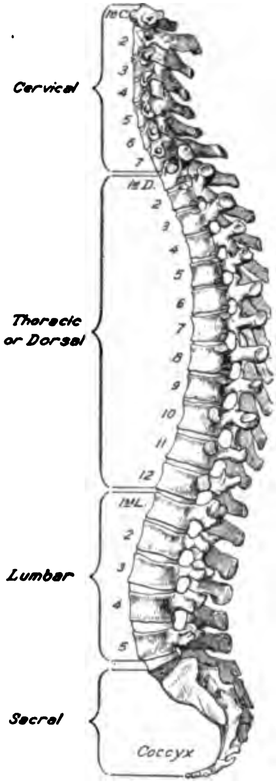
Another important use of the bones is to protect from injury the delicate and sensitive parts of the body. You can feel the strong box that the bones of your head form for the protection of your brain. The spinal cord, which is an extension of the brain, is guarded by the bony tube called the *spinal column.* You can feel also the strong framework of bone that protects the lungs and the heart.

The body of a new-born baby has as many bones as that of a full-grown man — 206. The bones are of different sizes and shapes, according to the use that is to be made of them. Some are long, as those in the legs and arms; some short, as in the wrist; some flat, as in the upper part of the skull; some curved, as in the ribs. By studying the picture of the skeleton and comparing it with your own body, you can easily locate all the principal bones and find out, if you wish, the names that have been given to them.

The most important and interesting of the bony structures of the body is the spinal column. It is necessary that it should

be strong enough to support the trunk and the head and protect the spinal cord. It must be flexible enough to bend with ease in any direction with the movements of the trunk, yet in such a manner that the delicate spinal cord within it will not be injured. This wonderful combination of uses is accomplished by the arrangement of a number of separate ringlike bones, one above another, bound together with bands of strong connective tissue. These separate ringlike bones are called the *vertebræ*. The bony column with the canal for the spinal cord running through it, is formed by the twenty-four vertebræ arranged one above the other, as is shown in the illustration.

The spinal column



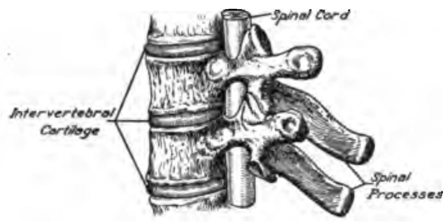
THE SPINAL COLUMN IS A BONY TUBE WHICH PROTECTS THE SPINAL CORD. NOTICE THE RINGLIKE BONES — THE VERTEBRÆ — SO PLACED UPON ONE ANOTHER THAT A PERSON CAN BEND FREELY IN ANY DIRECTION AND NOT INJURE THE DELICATE CORD WITHIN.

The vertebræ are separated from each other by means of disks composed of very elastic cartilage. These act as buffers to prevent friction and jarring which might injure the brain. A person who is much on his feet becomes shorter during the day by the thinning of the cartilages between the vertebræ; but he regains his height during the night. Most persons are half an inch taller in the morning than at night.

Buffers to prevent jarring in the body

You will notice in the picture that the spinal column is not straight but

forms a graceful double curve. It is upon the preservation of the natural curves of the spine that the poise and graceful carriage of the body chiefly depend. These curves also aid in giving springiness to the spinal column and so prevent the jarring of the head in walking or running.



NOTICE THE RINGS OF CARTILAGE BETWEEN THE VERTEBRÆ. NOTE ALSO HOW THE SPINAL CORD IS PROTECTED.

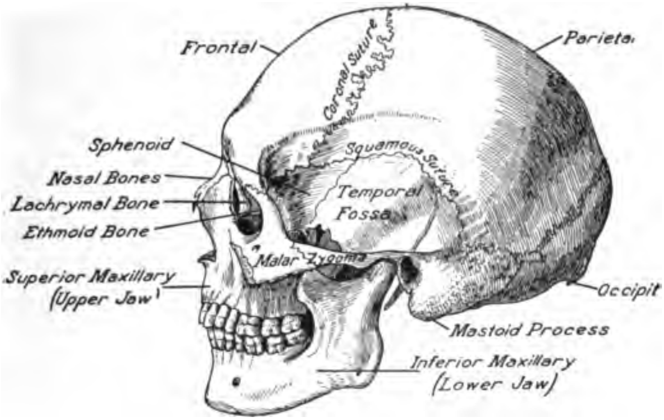
Notice the difference in the amount of jar the body receives in jumping with the legs straight and stiff and with the legs bent at the knees; also the difference in the jarring of the hand when the ground is struck with a straight stick and with a curved one. The curves in the spine, the arch of the foot, and the bending of the knee, as well as the cartilages separating the vertebræ, all aid in protecting the brain by giving greater springiness to the skeleton.

If the spinal column is broken it is quite impossible to stand or walk, because there is no support for the trunk, and the spinal cord which controls the movements of the muscles is injured.

The joints

If the bony framework of the body were all united in one piece, no movement of the different parts of the body would be possible. If, on the other hand, it were composed of disconnected bones, there would be no support for the body as a whole and it would not be able to stand upright. It is necessary that the bones should be joined together, but in such a way that the free movements of the parts will be possible. The places where the bones are united are called *joints*.

Where great strength but no movement is required, the bones are solidly united by *immovable joints*. Since there is no move-



MOST OF THE JOINTS IN THE HUMAN SKULL ARE IMMOVABLE. IS THIS A GOOD ARRANGEMENT? WHY?

ment at these joints, we cannot detect them in our own bodies, but they may easily be seen in the head of a skeleton.

In an immovable joint, the bones are firmly united by a piece of cartilage that grows between them. In a movable joint, a thin layer of cartilage covers the end of each bone, and this is kept lubricated, or moist, by an oily fluid poured out by a delicate membrane that incloses the joint. This enables the joint to work smoothly.

The joints are bound together by tough bands of connective tissue called *ligaments*. Besides holding the bones together, these ligaments also limit the movements of the joints.

There are several kinds of *movable joints*. In the *ball-and-socket joint*, the rounded end of one bone fits into a cuplike hollow in another bone. This kind of joint is found in the shoulder and the hips. It gives the greatest freedom of motion,

allowing movement in all directions, as you may see by swinging your arms or legs. *Hinge joints*, examples of which are found in the elbow and the finger, allow movement only in two opposite directions. In *gliding joints*, the bones move slightly upon each other, as at the wrist and ankle.

The vertebræ have a special kind of joint. They rock back and forth on each other, as they are pulled by the muscles

THE HIP JOINT IS A GOOD EXAMPLE OF THE BALL-AND-SOCKET JOINT. WHAT MOVEMENTS ARE MADE POSSIBLE BY THIS KIND OF JOINT?

that control them, the amount of movement being limited by the ligaments that hold them together.

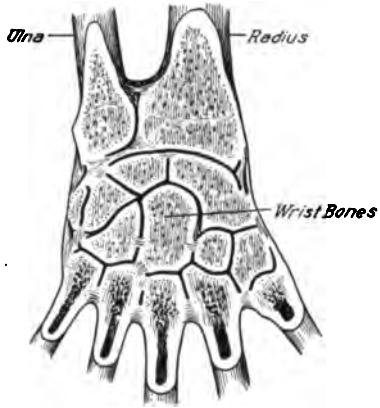
Injuries of the bones and joints

In consequence of a fall or a blow, the end of a bone is sometimes dislocated or "put out of joint." The ligaments about the joint are torn, and the bone slips out of place. On the occurrence of such an accident,

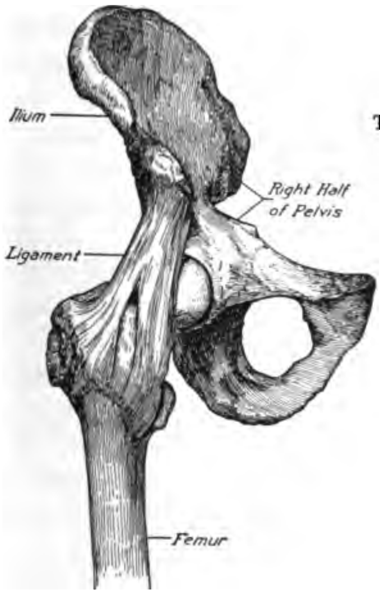
THE ELBOW JOINT ILLUSTRATES THE HINGE JOINT. WHAT MOVEMENTS ARE MADE POSSIBLE BY THIS KIND OF JOINT?

a physician should be called at once to replace the bone before the parts become swollen. Why will they swell?

A *sprain* is an injury due to a joint's being so badly strained that a ligament is torn from its fastenings to the bone. Bathing in water as hot as can be borne will keep down the swelling and relieve the pain. Why? Elevation of the injured member will also help to keep down the inflammation. Why?



THE BONES IN THE WRIST PERMIT OF A SLIGHT GLIDING MOVEMENT UPON EACH OTHER.



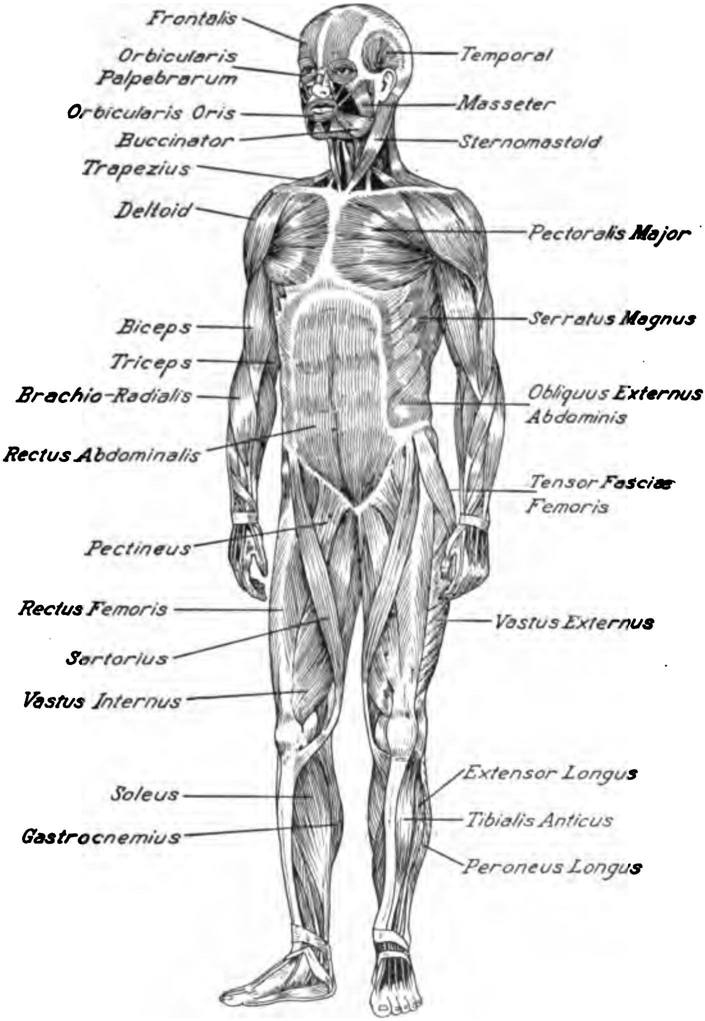
IN A SPRAIN, THE LIGAMENT THAT HOLDS THE BONES IN PROPER POSITION IN A JOINT IS STRETCHED OR TORN. IF THE HIP LIGAMENT — SHOWN IN THE PICTURE — SHOULD BE TORN THE HIP WOULD BE SPRAINED.

When a bone is broken, the muscles often draw the ends of the broken bone apart and a physician is required to put the parts back into their proper position. There may be sharp points on the ends of the broken bones, which are likely to tear the tissues if the limb is bent at the broken point. On this account, great care should be taken to keep the limb per-

fectly quiet until the physician arrives. After being "set," the ends of the bones must be held in position by splints and bandages until Nature has time to cement the parts together by the hardening of a substance poured out between and around the ends of the broken bone. This substance gradually becomes firm, making the bone nearly as good as before.

WHEN A BONE IS BROKEN A SURGEON SHOULD "SET" IT, AND THE PARTS SHOULD BE HELD IN PLACE BY SPLINTS AND BANDAGES UNTIL NATURE CAN CEMENT THEM TOGETHER THE ILLUSTRATION IS AN X-RAY PICTURE OF A BROKEN BONE.

The effects of tobacco poison in preventing proper development of the bones is so marked that even those who assent to its use by adults condemn its use by growing boys. We have already seen that tobacco injures the heart, the lungs, and the digestive organs, so that no part of the body gets its proper supply of food and oxygen. The bones suffer, as well as the rest of the body, from this lack. Besides this, the tobacco poison seems to have a special effect in injuring the bone cells and checking the development of the bones. A boy who at an early age begins to smoke cigarettes is likely to become dwarfed and stunted in body as well as in mind.



THIS PICTURE SHOWS THE MUSCLES OF THE BODY.

If you should fasten the bones of a skeleton together with artificial joints and then should try to make this framework stand upright, you would find that you could not do so; it would all fall together into a heap of bones. There must be something besides the joints to hold the bones together and keep them in their proper position. This work is done by the muscles. The skeleton could no more stand alone without the aid of the muscles than the muscles could stand without the skeleton.

Keeping straight

It is of great importance that every group of muscles in the body should be well developed so that the skeleton may be held correctly. It should be supported equally on every side, like the masts and spars of a full-rigged vessel.

We bear in our bodies as we grow older a record of the way we have stood, walked, and sat. Will this boy have a fine record?

This is necessary, in the first place, that one may have a good appearance. We bear in our bodies a record of our habits that may be easily read by a trained eye. A slouching body and a shuffling walk create a most unfavorable impression of carelessness, laziness, and lack of dignity and self-respect. A boy who walks

with head erect and shoulders well squared gives an impression of energy and self-respect which is of great advantage to him. A girl with a fine carriage and graceful walk makes a much finer appearance than one who neglects to hold herself erect and who walks with a careless gait.

A FINE CARRIAGE IS IMPORTANT BOTH TO HEALTH AND TO APPEARANCE.

We are in some respects the architects of our own bodies. It is more or less in our power to determine the shape of the body. Especially in youth when the bones are pliable and the muscles supple, we may, according to our habits, influence the position of the bones and their relations to each other. We may then determine whether we shall have well-shaped bodies and erect carriage that will recommend us to others or awkward carriage and ungainly bodies that will always be a handicap to us.

The symmetrical development of the body is of even more importance for the sake of health than for that of a good appearance. An external deformity usually means a corresponding internal deformity; the latter is of far greater importance than the former. Round shoulders, for instance, are always accompanied by a flat chest. This means that the lungs are compressed and, therefore, that the breathing capacity is lessened.

It is only by exercise that the suppleness of the body, the elasticity of the muscles, and the flexibility of the tendons and




THE EXERCISES SHOWN IN THE PICTURES ARE FINE FOR GOOD POSTURE.

ligaments can be preserved. If the muscles of a certain part of the body are not used in such a manner as to stretch them, they may become shortened and, after this, stretching them will be impossible. If the arm be kept bent for a long time, it may become impossible to straighten it, because the muscles of the inner side of the arm will have become shortened through not being stretched. In this way, deformities may be produced when bones have been pulled out of place, for the bones may be permanently held in a wrong position by a shortening of the muscles.

How deformities are caused

The vertebræ of the spinal column are moved by the contracting and lengthening of the muscles attached to them. When the spine is curved on the left side, the muscles on the right side contract and are shortened, and a curvature of the right side means a shortening of the muscles on the left side. When the body, in sitting, standing, or working, is habitually held in an improper position, some of the muscles may become permanently shortened, causing a life-long deformity, known as spinal curvature. A backward curvature of the spine, manifested by round shoulders, a flat or hollow chest, and forward carriage of the head, is by far the most common form of spinal curvature. If the muscles of the back are relaxed, the spine

WHEN A GIRL SLOUCHES IN HER CHAIR, AS THIS ONE DOES, SHE WILL BECOME NARROW-CHESTED AND SHE WILL FEEL AS DUMPISH AS SHE LOOKS.

naturally forms a backward curve. This is what makes the chest flat. The trouble is not in the chest, but in the spine, and the curvature of the spine is due to the relaxation of the muscles of the back, which allows the spine to bend unduly.

It is very important to remember that the bones are affected by what we eat. In order that the bones may grow large and strong, the food must contain an abundance of lime. This is found in all kinds of green vegetables, such as turnip tops, beet tops, greens of all sorts, in milk, in yolk of eggs, and in such whole grains as oatmeal and wheat flakes. Almost no lime is found in bread made with fine flour, in rice, in the specially prepared corn meal, in potato, or meat, and none at all in sugar or honey.

In the back of this book will be found a table giving the foods that are richest in lime and iron.

Every growing child needs daily not less than fifteen or twenty grains of lime. The quantity of food required to furnish this amount is shown in the table referred to above.

Health Problems

1. Suppose a boy five years old and a youth twenty years old should accidentally slip when climbing a tree and fall a distance of fifteen feet. Do you think it probable that either would break the bones in his leg or in some other part of his body? Which do you think would be more likely to escape injury? Explain.

2. Suppose a man fifty years of age were climbing in place of the boy of five, which one of the persons falling would then be more likely to suffer?

3. Suppose a boy of five, a young man of twenty, and a man of fifty years should each break a bone in his leg. Which one of the three persons do you think would recover soonest? Explain.

4. Try the experiment of taking the lime out of a bone and notice what happens to it.

5. Try the experiment of burning the animal part out of a bone and notice what happens to it.

6. Try the experiment of holding your body perfectly stiff and then jumping up and down on your heels, though not very high, of course. How do you feel? What reason can you give for this experience?

7. Point to some immovable joints in your own body. Why did Nature not make them movable?

8. A boy I know had his leg broken in a football game. He did not have the surgeon called at once. It is now six months since the accident occurred, and the break has not yet healed, though otherwise he is perfectly healthy. What do you think may be the explanation of this?

9. Mention some deformities you have noticed which could have been avoided by good habits of sitting, standing, and walking.

Review Questions

1. What makes up the framework of the body?
2. Of what is the skeleton of a new-born baby composed?
3. What is the cause of such deformities as knock-knee and bowleg?
4. What makes the bones hard? Describe the different parts of which the bone is composed.
5. What kind of food do young children need in order to build their bones?
6. What is the periosteum?
7. Why did nature not make the large bones of the body solid?
8. How does nature secure lightness and strength in bones?
9. What are the uses of the skeleton?
10. By what arrangement do the muscles move the bones?
11. What is the spinal column?
12. How is the spinal column made flexible?
13. What are bones in the spinal column called?
14. What is the use of the disks that separate the vertebræ?
15. Of what value to the body is the double curve in the spine?
16. What are the ways in which Nature tries to prevent too great jarring of the brain when one walks, runs, or jumps?
17. If the spinal column should be broken, what would happen to the body?

18. What is the purpose of the joints that connect the bones? What is meant by immovable joints? Mention some of these joints. What is meant by movable joints? Mention some of these.

19. What is the use of the ligaments in the body?

20. Give an example of the ball and socket joint; of the hinge joint; of the sliding joint.

21. What is a sprain? How should one treat a sprain?

22. What should be done in case a bone is broken?

23. What is the effect of tobacco on the bones?

24. What is needed besides bones and joints to keep the body upright?

CHAPTER XII

The Body in Motion

Every movement of a living creature is made by means of muscles. The flight of a bird in the air, the rapid moving of an insect's wings, the gliding of a snake along the ground, — all animal movements of whatever kind are made by means of muscles.

Kinds of muscles

There are two kinds of muscles in the human body: those which are under the control of one's will, called *voluntary muscles;* and the *involuntary muscles* which one cannot control by just willing to do so. Five hundred pairs of voluntary muscles are the servants of the will in performing the different kinds of work of which the body is capable. The number of the involuntary muscles is too great to be estimated. The skin is a perfect network of little muscles. Every hair has a minute muscle attached to it by means of which it may be made to stand erect. The stomach is a muscular sac, the intestines a muscular tube, the air tubes of the lungs have muscular walls, and the heart, the great pumping organ of the circulation, is a wonderful muscular engine.

The involuntary muscles act according to the needs of the body and quite independent of one's will. They are at work for us when we are asleep, as well as when we are awake, keeping the heart beating and the lungs active. When food is swallowed, it is seized by the involuntary muscles and carried into the stomach, worked upon, and moved from point to point until it is digested. By means of these muscles, the blood is circulated and the supply to each part is regulated. All their work is done

with faithfulness and loyalty to the well-being of the body, even when the voluntary muscles controlled by the will are

MUSCLES HAVE DIFFERENT SHAPES AND SIZES ACCORDING TO THE SPECIAL WORK EACH HAS TO DO.

working against the body's interests. Think of some instances that will illustrate this.

The muscles are of different shapes and sizes, according to the work for which they are designed. Some are shaped like a spindle, some like a feather, some like a fan, and still others are ring shaped.

MUSCLE FIBERS HAVE THE POWER TO CONTRACT, BECOMING SHORTER AND THICKER. THEY ARE TIED TOGETHER IN BUNDLES BY CONNECTIVE TISSUE.

The cells which compose the voluntary muscles are the largest and most active in the entire body. They form the muscle fibers, which are long, slender structures. They have the power to contract, or draw themselves up as a worm does in crawling, becoming shorter and thicker. The muscle fibers are held together by a framework of connective tissue, which divides the cells into groups and ties them up into bundles.

The lean part of meat is muscle. A boiled piece of lean corned beef may be easily sepa-

rated into small bundles. These bundles may, by the use of needles, be separated into bundles still smaller. These last small threads are the muscle fibers.

Nearly all the voluntary muscles are attached to the framework of the body, the skeleton, because the bones are the levers by means of which movements are made. Each muscle is usually attached at two points. The point which is less movable, or which is nearest the center of the body, is called the *origin*, and the other the *insertion*. At the end of each muscle, a continuation of the connective tissue sheath is joined to the periosteum, thereby attaching the muscle to the bone. In this way nearly every muscle passes over a joint and is attached to two separate bones, thus making the muscles an important means of holding the bones of the skeleton together.

How muscles are attached to bones

THE FOOT IS SHOWN USED AS A LEVER. ILLUSTRATE THE PRINCIPLE BY USING YOUR OWN FOOT. CAN YOU FEEL THE MUSCLE OF THE CALF ACT? DESCRIBE IT.

The connective tissue does not always pass directly from the muscle into the periosteum. Sometimes the tissue forming the sheath unites at one or both ends to form a white cord-like structure called a *tendon*, by means of which it is attached to the bone. Some muscles have tendons at each end, some at the point of insertion only, and still others have none at all.

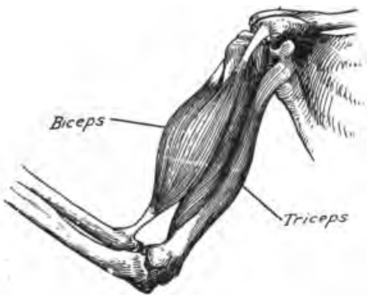
Sometimes the point of insertion, or the place where the tendon is attached to the bone, is at some distance from the muscle itself. If all the muscles necessary to give to the hand its strength and

variety of movement were attached directly to the bones of the hand, it would be very heavy and clumsy. The hand is moved by muscles in the arm, to which it is attached by long, slender tendons. When the hand is opened and closed, the tendons which attach the fingers to the arm muscles may be seen in the wrist, and the movements in the muscles in the arm may be distinctly felt.

It is of more importance to us to know how muscles act and what the relation of their action is to the work and needs of life than to know the particular names that have been given to them or to the bones to which they are attached.

How muscles act

When the cells of a muscle contract, the whole muscle is shortened. In shortening, each fiber thickens, so that there is no change in the actual size of the muscle but only in its form. The shortening of the muscle causes it to pull upon the bone to which it is attached, and this results in the bending of the joint over which the muscle passes, and a movement of some part of the body. You can easily see this for yourself by placing your hand upon the large *biceps* muscle in the upper arm and noticing the shortening and thickening of the muscle by means of which the arm is bent at the elbow.



THE FOREARM IS SHOWN USED AS A LEVER. ILLUSTRATE THE PRINCIPLE BY USING YOUR OWN ARM. CAN YOU FEEL THE BICEPS ACT?

The muscles can by their contraction only pull on the bones. The biceps muscle can pull up the forearm, but it cannot push it back into place. The forearm has to be pulled back by another muscle. If you bend your arm at the elbow and place your hand

upon the back of the upper arm while you straighten it out again, you will feel the tightening of the *triceps*, the muscle which pulls down the forearm and holds it in place.

A great many of the voluntary muscles are arranged in pairs of *antagonistic muscles*, working against each other in the way the biceps and triceps do. Antagonistic muscles, with their steadying pull, one against the other, act as brakes which keep the movements from being jerky and spasmodic, as they otherwise would be. Most of the bodily movements, as those of the arms and legs, or even the simple act of standing erect, require the action of many muscles, each of which is balanced by some other one.

Keeping muscle tone

If a muscle is cut, it will immediately shorten like a piece of rubber released from a stretched condition. The muscle is always more or less stretched or taut when it is alive and healthy. This tension in the muscle is what is called *muscle tone*. The muscle tone is kept up by a stream of energy pouring into it from the nerve centers. When one is tired out, this energy is exhausted, the muscles lose their tone, and there is a relaxed condition. That is why a person who is tired or weak lets his head droop and his chest collapse. When one goes to sleep in a sitting position, the head "nods" or drops forward, because the muscles that hold it in position become relaxed.

We can feel and see the contraction of a working muscle, but there is another important change taking place in it that we can neither see nor feel. As the muscle begins to contract, its arteries dilate and fill with blood, for it is the blood that brings to the muscle the energy that it requires for work. A working muscle is warmer than one at rest, for the reason that muscular contraction is always accompanied by the burning up of some of the food material which is stored in the muscle and brought to it in the blood.

When any large group of muscles, for instance those in the legs, are set in active operation, as in jumping or running, one very quickly gets out of breath. This is due to the fact that when the muscle is at work it throws into the blood which passes through it a large quantity of carbonic acid gas, which is poison to the body and must be hastened out through the lungs. The greater the amount of this gas thrown into the blood, the quicker one becomes out of breath and the more rapid the breathing movements become. At such times the lungs are expanded to their utmost capacity. Why?

The effect of fatigue

If the exercise is less violent, but continued for a longer time, one may not get out of breath, but after a while the muscles will become wearied, so that movement is difficult and may even become impossible. This fatigue, or exhaustion, is due, not to the using up of the muscle's store of energy, but to the formation of those poisonous substances that result from the muscle work, which we have already studied, and which have a harmful effect upon the muscle.

The muscle is a machine which may be compared to a locomotive, since it carries its own fuel. This fuel is stored up in the muscle in the form of glycogen, or animal starch, which when needed is converted into sugar. In work, the sugar is converted into carbon dioxide and *lactic acid*. These products are muscle poisons. As work continues, the amount of oxygen and glycogen stored up in the muscle is lessened and the poisons accumulate. This hinders the muscle in its work. It is in the situation of a locomotive whose fire is choked with ashes while its fuel is low. This is real fatigue.

Exertion may be carried to such a point that death may result from the fatigue induced. Runners have sometimes dropped dead at the end of a long course. Horses have been known to die suddenly from the same cause, and dogs also have died

when attempting to keep up with a bicycle or automobile. Carrier pigeons not infrequently fall to the ground dead from exhaustion after a long and rapid flight. In such cases, death is due to the rapid accumulation of the poisons formed by too prolonged action of the muscles.

It is interesting to notice that exercising a part of the body may cause the whole body to become fatigued. For example, one's arms may become tired as the result of running. How can the poisons formed in the leg muscles get to the arm muscles?

Every movement of a muscle is made in response to an impulse which it receives from the nerves. From the brain or the spinal cord a nerve goes to every voluntary muscle in the body. Prolonged muscular work wearies the brain and nerves as well as the muscles, partly by reason of the fatigue poisons circulating in the blood. One is likely to become fatigued easily when performing exercise to which he is not accustomed. Why?

Curing fatigue

If one who is fatigued will rest for a time, the feeling will probably disappear. Rest generally cures fatigue and puts the muscles in trim for work again. Rest gives the muscles opportunity for increasing their store of oxygen and glycogen and also for the washing out by the lymph and blood of the poison with which they have been filled by work.

A very short hot bath will lessen fatigue, because it will stimulate the circulation of the blood and in that way hasten the removal of the fatigue poisons. A prolonged hot bath will aggravate the feeling of fatigue, and it may even produce a feeling of exhaustion. Why? A short cold bath will also relieve fatigue through its general stimulating effect upon the body. One may fortify himself against fatigue by cold bathing, by providing the muscles with an abundant supply of muscle starch or glycogen and by deep breathing of pure cool air.

After prolonged and violent exercise, especially exercise to which one has not been accustomed, one may find himself suffering from muscular soreness and stiffness, together with a feeling of great lassitude. These feelings do not usually appear until some hours, perhaps a day or even longer, after the exercise producing them. This is called secondary fatigue.

After effects of fatigue

The fatigue caused by a short period of exercise is soon overcome and may disappear within a few minutes. The longer and the harder the work performed, the longer the period of rest required. The soreness and stiffness which accompany secondary fatigue usually disappear in a few days. Unless the exercise has been exceedingly violent so that the parts used have been strained or injured in some other way, the muscles will after a few days become stronger than before the practice and able to endure more work. The same exercise may then be repeated without bad effect. The soreness and stiffness which follow the first attempts with any new form of exercise should not discourage one. They should be regarded as an indication that Nature is preparing the muscles for better service by strengthening the muscular fibers and storing up a larger amount of energy.

Health Problems

1. Which of the actions of your body occur without your control?
2. Take a piece of lean meat which has been thoroughly boiled and separate it into muscle fibers. Be careful that you do not stop with bundles of fibers.
3. See if you can trace two or three muscles in your own body from origin to insertion.
4. Why did Nature make tendons? Why did she not fasten the muscles directly to the bone which she wanted to move by them?
5. Suppose the triceps in the right arm to be cut. How would the arm behave? Explain.

6. Try closing your fist as tight as you can and then opening it quickly, repeating these movements with great rapidity as long as you can. Describe your experience. If you should reach a point where you could not close the fist longer, explain why this would happen.

7. Describe some experience of yours which has made your muscles stiff the day afterward. Explain.

8. Write an essay on keeping the muscles in good working condition.

Review Questions

1. Mention some of the various movements which we can execute and which require the use of the muscles.

2. What are the voluntary muscles? The involuntary muscles? Why are they so called?

3. How many pairs of voluntary muscles are there in the human body? How numerous are the involuntary muscles?

4. What do the involuntary muscles do for the body to keep it in health?

5. Are the involuntary muscles more faithful than the voluntary muscles? Why?

6. Tell something of the different shapes and sizes of muscles.

7. Describe a muscle fiber. How are the muscle fibers arranged in the muscles?

8. What part of meat is usually composed of muscle fibers?

9. How are the muscles attached to bones? What are the names of the points where the muscles connect with the bones?

10. Describe a tendon and explain its uses.

11. What happens when the cells of a muscle contract?

12. Tell how the muscles move the bones.

13. Where is the biceps muscle? Where is the triceps muscle?

14. Why are the muscles arranged in pairs working against each other?

15. What will happen to a muscle when it is cut?

16. What should we do to keep up muscle tone?

17. Explain why a person who is tired lets his head droop and his chest collapse.

18. What change in the character of the blood takes place in a muscle when it contracts? What is the purpose of this change?

19. Why does one get out of breath when he is running?

20. What does it mean to become fatigued? Does one become fatigued because his muscles wear out or from some other cause? May overwork of one muscle fatigue the whole body? Explain.

21. What may happen to a person if he exerts himself until he is completely exhausted?

22. What is the best way to relieve fatigue? What is the value of hot and cold baths in relieving fatigue?

23. What causes secondary fatigue?

CHAPTER XIII

HEALTH AND SYMMETRY

ONE'S daily work usually provides much opportunity for healthful exercise. For girls, general housework — sweeping, dusting, making beds — gives splendid exercise, bringing into play the whole muscular system. For boys, no general exercise excels that which may be secured in "doing chores" about the house. Splitting and carrying wood, running errands, mowing the lawn, weeding the garden, if done heartily, give good exercise for all parts of the body.

SWEEPING IS A FINE EXERCISE FOR DEVELOPING THE ARM MUSCLES.

Using one's daily tasks for muscle training

Working in the open air is much more beneficial than working indoors. In cultivating flowers, vegetables, and small fruits, — digging, hoeing, pruning, — one is at the same time cultivating health and muscular development. The ancient Greek boxers practiced digging as a means of developing their arm muscles.

In order to be of the greatest benefit, exercise should be enjoyable. We know that appetite is necessary to good digestion. In the same way, exercise that is taken without relish, merely as one takes a dose of medicine for the sake of health, will not do us so much good as that which is connected with some interesting work or pleasure that makes it a delight.

Outdoor games and sports are among the best forms of exercise because they give at the same time fresh air and enjoyment.

The best forms of exercise

The exercises that are most beneficial to the body in a general way are those that bring into play the large muscles of the body, especially those of the legs, as in running, swimming, hill climbing, and rapid walking.

Walking, in these days of steam cars, street cars, automobiles, telephones, and the like is becoming a negligible exercise. The city youth who wishes to go a few blocks usually jumps on the trolley car. The country boy "hitches up" or takes the Ford every time he has to go a mile. But in gaining a little time, how much physical benefit may be lost! Some one has suggested that if a magical physician were "to invent an elixir that imparted a tenth part of the virtue of a day's walk in the open air, he would be the Crœsus of pill makers. How much would we give for a bottle of his concoction! Yet we may walk for nothing, and we may begin to-day."

Do you know that when walking at the rate of four miles an hour you breathe five times as much air as when you are sitting still? What effect do you think this has upon the development of your chest? The natives of Hindustan, when they see a man going out for a walk, say, "He goes forth *eating air*." "If," says one authority on health, "every boy in the United States would take daily one thousand slow, very deep breaths from now on throughout his life, it would almost double our vigor and effectiveness as a nation."

Robert Burdette gave this advice to a young man: "Live out of doors all you can, my boy. Walk a heap. The open air,

EDWARD PAYSON WESTON WHEN IN HIS SEVENTY-SECOND YEAR WALKED FROM SAN FRANCISCO TO NEW YORK.

the free air, and the sunshine are as good as the exercise — better."

The man who has done much, by a remarkable example, to encourage walking is Edward Payson Weston. When he was twenty-nine years old he created a sensation by walking from Portland, Maine, to Chicago, Illinois. Forty-three years later, he walked from San Francisco to New York, celebrating his seventy-second birthday, on the way, by walking seventy-two miles.

A twelve hundred mile walk

Do you think Weston could have performed this feat that attracted the attention of the whole country if he had neglected personal hygiene and regular physical exercise? His performance is especially remarkable as showing that a man of over three score and ten years may, after more than forty years of temperate living and rational exercise, be able to endure the same physical exertion that he could before he was thirty. Weston himself expressed the hope that his trip "would serve to show the young people of America what right living will do for one." Mr. Weston uses neither tobacco nor alcohol.

Mr. Weston stated to the writer that he never eats meat when he is taking a long walk, but confines himself to the simplest and most digestible foods, living almost wholly upon cereals, milk, and fruits.

It is interesting to calculate the amount of work one performs in different kinds of exercise. In walking, for example, the amount of work done is much larger than would be supposed. An eminent physiologist has demonstrated that in walking at the rate of three miles an hour, one uses the same amount of energy that would be required to lift his body vertically through one thirteenth the distance that he walks. That is, to walk thirteen feet requires as much energy as to lift one's self one foot. If a boy weighs 100 pounds he would use up 100 foot pounds of energy in walking thirteen feet. It has been estimated that the amount of muscular

Estimating the amount of work done in exercise

work needed daily in order to keep one in health is about 150 foot tons.

It is evident that a very fat person will accomplish a larger amount of work in traveling a given distance than a thin person, because he carries so much dead weight. The man who weighs twice as much as he should practically carries another man on his shoulders. This renders walking much more difficult.

In going upstairs one is obliged to lift the body through the distance from the lower floor to the upper. If the distance were ten feet, and the weight of the person 170 pounds, this ascent would involve an amount of work equivalent to the lifting of 1700 pounds one foot into the air. You can calculate from your own weight and the distance between the upper and lower floors in your house the amount of work involved in lifting your body from the lower to the upper floor, and how many times it would have to be done to accomplish the necessary amount of daily exercise, if it were all to be taken in this way.

THIS EXERCISE IS VALUABLE FOR THE DEVELOPMENT OF POISE AND AN ERECT POSTURE.

Taking exercise in one's room

When one's daily work does not involve the necessary amount of exercise, and it cannot be taken out of doors, it may be easily taken in one's room if desired, in such exercises, for example, as standing erect and alternately raising and lowering the heels; bending and extending the knees; supporting the body upon the hands between two chairs or other supports, and letting the body down as low as possible and then raising it to position — the so-called "dipping movement" in which the arms do the work.

A person practicing heel raising at the rate of 100 movements a minute for twenty-four minutes, rising two inches each time, would do as much work as in walking a mile. How long would a man weighing 150 pounds have to continue this exercise to do the muscular work of 150 foot tons?

The best time to exercise

Some people take a long walk now and then; others crowd the chief part of their year's exercise into a few weeks' holiday in the summer. Of course this is much better than none at all, but the body needs its daily portion of exercise as much as it needs its daily portion of food. In fact, exercise is necessary in order for food to be properly assimilated. It would be about as sensible to undertake to do a month's eating in a single day as to take all one's exercise for a month on a monthly holiday.

Exercise regularly, if possible at the same hour each day. The body will then form the habit of exercise and will unconsciously brace itself for the work expected. Between ten and twelve in the forenoon is the best time to exercise, and the next best time is between four and six in the afternoon. Immediately after one rises in the morning is, however, a good and convenient time for most healthy persons.

How fatigue affects the muscles

Much greater benefit is derived from moderate exercise many times repeated than from violent exercises repeated a few times. One not accustomed to exercise vigorously should begin with light exercise, always stopping short of extreme fatigue and increasing the amount of muscular work from day to day. The lifting of heavy weights or the performing of other work too heavy for the muscles may permanently injure them.

In order to study the effects of fatigue on the muscle, experiments have been made with muscles taken from frogs, which retain their vitality for some time after being removed from

the animal. When such a muscle is stimulated by electricity, it is found that its contraction and relaxation gradually become slower. There is an increase of power during the first ten or twelve contractions, but after that the muscle becomes weaker and weaker until it cannot be made to contract at all. If left to itself the exhausted muscle will recover in an hour or so. But if the muscle is washed with pure blood or with a salt solution, it will recover immediately. If the blood of a dog fatigued by excessive exercise is injected into the veins of a fresh dog, the latter at once shows signs of fatigue. Explain why the exercise of a part of the body will fatigue the whole body.

An exercise to which a person is not accustomed is generally more fatiguing than one to which he is accustomed, though the latter may involve much more actual work. The amount of fatigue is more nearly proportioned to the difficulty of the work than to the amount done. For instance, suppose a person is made to walk on a straight line. In one way, it is little more labor to carry the body on a line or on a flat fence top than it is to walk on the sidewalk. Yet if you try the experiment by walking, for instance, upon a train track rail for half a mile, you will find it much more tiresome than walking upon a broad path, where no effort is required to keep the balance. Why is this? It is because one's nervous energy is used up in maintaining balance.

Exercise for symmetrical development

Most employments that are not sedentary give a sufficient amount of exercise to maintain health. Some employments, however, give undue exercise to special muscles, and this may lead to deformities. A carpenter or a blacksmith may generally be distinguished from other workers by the way in which he carries his arms. The strongly developed *flexor muscles* overbalance the *extensors* (point out these muscles) so that the arms are constantly bent when they are at rest as well as when they are at work.

A BLACKSMITH'S FLEXOR MUSCLES ARE USUALLY SO MUCH BETTER DEVELOPED THAN HIS EXTENSOR MUSCLES THAT HIS ARMS ARE CONSTANTLY BENT EVEN WHEN HE IS AT REST.

Ignorance, carelessness, or weariness often lead a person to assume awkward and unhealthful postures while he is engaged in work, and this habit may result in fixed deformities. It is, of course, of great importance to maintain a correct poise during work.

It is also necessary to give a little thought to the matter so as to prevent a one-sided development. Most persons use the muscles of the right side much more than those of the left. Nearly all manual work requiring strength or dexterity is done with the right hand. Even the right leg usually has enough more training than the left to make it a little larger. The extra work done by the right side of the body increases the strength of the muscles

of this side, causing the spine to curve toward the left side, and the right shoulder to drop a little. Probably three persons out of four have this deformity in some degree, but with proper physical training it may be avoided or overcome.

PROBABLY WITH THREE OUT OF EVERY FOUR PERSONS THE RIGHT SHOULDER IS AT LEAST A LITTLE LOWER THAN THE LEFT. WHY IS THIS SO?

Even those engaged in muscular work require special exercise as a rule to bring into play the rest of the muscles of the body and secure symmetrical development. A man might sit down by the roadside and spend ten hours a day breaking stones with a hammer, as men may be seen doing on the roadways of England, and the active exercise would give him a good appetite, sound digestion, and strong arm muscles; but the rest of the body, if neglected, would become seriously deformed. His limbs would become stiff, his gait feeble and awkward, and all symmetry of form and grace of movement would be lost.

Corrective exercises

An important point to remember is that a little exercise taken in the right position will help to counteract long-continued exercise in the wrong position; because in the one case we are working with Nature and in the other against her. For this reason a little *general* exercise of the whole body, taken in a correct posture, will have the effect of preventing deformities that might otherwise be caused by one's work. It is a good thing, however, to give *special* exercise to those muscles that have been too long stretched or contracted.

One whose back has been bent at his work may save himself

from round shoulders and a backward curvature of the spine by spending five or ten minutes, several times during the day, in vigorous exercise of the back and arm muscles with the spinal column in the erect position. The chest muscles which have been inactive should also be specially exercised.

A GOOD EXERCISE TO CORRECT ROUND SHOULDERS AND A FLAT CHEST IS TO RAISE THE CHEST AS HIGH AS POSSIBLE, DRAWING IN SLOWLY A LONG, DEEP BREATH, AT THE SAME TIME PRESSING THE BACK OF THE NECK HARD AGAINST THE COLLAR.

A good way to correct round shoulders and a flat chest is to raise the chest as high as possible, drawing in slowly a long, deep breath, and at the same time pressing the back of the neck hard against the collar. Do this repeatedly. It will bring the spinal column into the correct position, straighten out the back between the shoulders, and deepen the chest. Persons who have round shoulders and flat chests should sleep on a hard mattress, with a very thin pillow or none at all.

When the head is constantly bent forward in studying or working, the muscles at the back of the neck that support the head lose their tone from being continually in a stretched position, as a piece of elastic overstretched loses the power to contract. Unless the muscle tone is restored by suitable exercise, the droop of the head may become permanent. A splendid exercise for the muscles of the back is to lie upon the floor face downward, and then move the head up and down, raising the head upward as far as possible. Any other exercise that draws the head upward and

backward will help to strengthen the muscles that hold the head erect.

The strength of the abdominal muscles, the elasticity of which, as we have seen, has such an important relation to the health of the body, may be greatly increased by the following simple exercises: walking on tiptoe with the chest held high; running around the room on all fours; lying on the back, with the legs held straight, raising them to the perpendicular, repeating ten to twenty times three times a day; lying on the back and raising the body to the sitting position with the hands placed at the back of the neck.

THE ABDOMINAL MUSCLES SHOULD ALWAYS BE KEPT IN GOOD TONE, FOR THEY HAVE AN IMPORTANT EFFECT UPON THE HEALTH OF THE BODY. THE EXERCISE SHOWN IN THE PICTURE IS GOOD. THE LEGS SHOULD BE RAISED AND LOWERED.

One whose work keeps his hands bent continually, as in rowing, shoveling, or writing, may counteract the effects of this by forcibly extending the fingers as much as possible several times in succession, at intervals during his work. The feet also, because they are so constantly restricted by shoes, should be given stretching and contracting exercises to prevent weak arches.

Health Problems

1. How far do you walk in going to school? Is the road level or does it go up and down hill? About how many times should you have to walk this distance in order to do 150 foot tons of work?

2. Suppose two men equally tall, one weighing 270 pounds and the other 175 pounds, walk a mile together. Which has done more work at the end of the mile? Why?

3. In running a long-distance race, athletes do not start out at the height of their speed, but run only moderately fast at first. Why do they do this?

4. Perhaps you know persons whose arm muscles are strong and well-developed, but who cannot handle a pen or a needle easily. What is the reason for this? What muscles does a blacksmith train? A writer? A needleworker?

5. Observe how many of your classmates have one shoulder higher than the other. What is the cause of this? How may it be remedied?

Review Questions

1. What is necessary in order that exercise may be of the greatest benefit?

2. What kinds of work can a girl do that will give her much healthful exercise? What kinds can a boy do?

3. What sports afford the best exercise?

4. Why is walking so beneficial an exercise?

5. Tell about the achievements of Edward Payson Weston.

6. How much daily exercise is needed in order to keep one in health?

7. Describe some good general exercises which may be taken in one's room.

8. Is it well for a person to crowd all his exercise for the year into a few weeks in the summer? Why?

9. What is the best time for taking exercise?

10. What is the effect of tight clothing upon one who wears them while exercising or at any time?

11. Why is very violent exercise repeated a few times not so beneficial as moderate exercise repeated many times?

12. What effect does fatigue have on the muscles?

13. Why does exercise of a part of the body fatigue the whole body?

14. What is the effect of overexertion upon the muscles?

15. Why is work to which a person is not accustomed more fatiguing than work to which he is used, although the latter may require more muscular effort?

16. Explain how certain kinds of work cause a one-sided development of the body.

17. Describe an exercise which will correct round shoulders.

18. Describe an exercise which will strengthen the abdominal muscles.

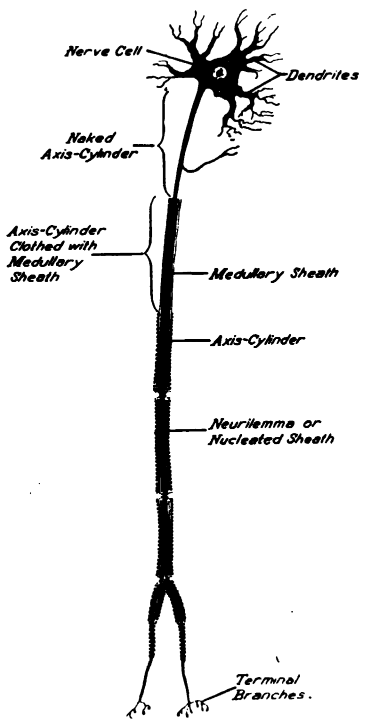
19. How may one whose work keeps his fingers bent prevent them from becoming crooked?

20. Why do the feet need special exercise?

CHAPTER XIV

FEELING AND THINKING

IF a community of people are to live and work harmoniously together, they must have some kind of government. The body community must also have its government. The ruler of the body is the mind working through the nervous system.



HERE IS A DIAGRAM OF A NERVE CELL AND ITS BRANCHES. NOTE THAT THE LONG NERVE FIBER IS REALLY A PART OF THE CELL.

It is in response to commands sent out through the nervous system that the digestive organs begin to work when food is eaten; that the lungs and heart work faster to increase the breathing when we run, so that a greater amount of oxygen may be carried to the muscles; and that the skin pours out perspiration to cool off the body. The nervous system brings all the cells and organs into communication, causing them to work together for the common good.

There are two forms of nerve tissue: *nerve cells* and *nerve fibers*. The nerve fibers are really additions to the cells, or parts of

them. Most nerve cells send out two or three slender arms, one or more of which may be prolonged into nerve fibers; and others connect with the branches of other cells or end in the spaces between the cells. A nerve cell with its branches is called a *neuron*. A careful examination of the branches shows that they are covered with minute buds. It is supposed that these buds are for the purpose of communicating directly or indirectly with other cells.

DO YOU SEE HOW THE MIND WORKING THROUGH THE BRAIN, SPINAL CORD, AND NERVES CAN CONTROL ALL PARTS OF THE BODY?

The nerve cells are usually found in groups, and each group has its own particular work to do in the government of the body. A group of nerve cells having some special work is called a *nerve center* or *ganglion*.

The little bundles of nerve fibers which pass out from a nerve center unite to form larger bundles, which pass to the different parts of the body. When the body of an animal is dissected, white, glistening cords are found running everywhere among the tissues. These bundles of nerve fibers are called *nerves* or *nerve trunks*.

There are two divisions of the nervous system, just as there are two of the muscular system. All the involuntary muscles, those not under the control of the will, are governed by what

is called the *sympathetic nervous system.* The voluntary muscles are controlled by the *central nervous system.*

The *brain* and the spinal cord are the great centers of the nervous system. In the brain lies the power by which we feel, think, and will. The brain is simply an assemblage of nerve cells or neurons, hundreds of millions of them. With the exception of the whale and the elephant, the brain of man is larger than that of any other animal.

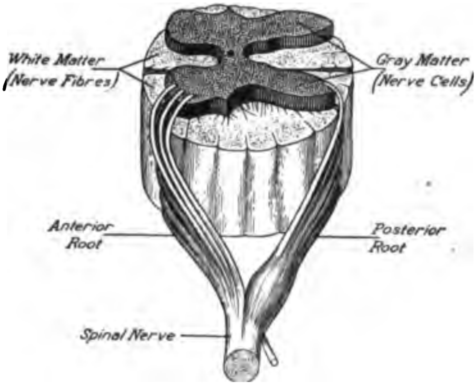
THE BRAIN, THE SPINAL CORD, AND THE ROOTS OF SPINAL NERVES ARE HERE SHOWN.

The spinal cord enters the *cranium* (the skull) and connects with the brain through a large opening at the base of the skull. The cord is a soft white substance, about the thickness of a pencil. It passes through the canal of the backbone, which forms a protection for it. It is also protected by membranes as is the brain.

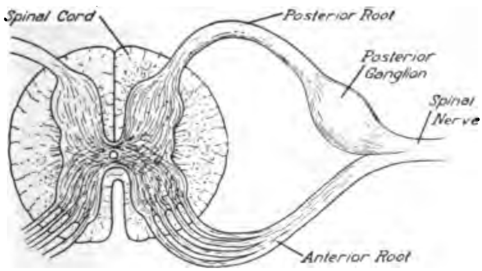
The brain and the spinal cord send out nerves to the different parts of the body, forty-three pairs in all. Twelve of these arise from the under side of the brain and are called *cranial nerves.* They pass through small openings in the base of the skull and are distributed to the face, the organs of sense, — eye, ear, nose, and mouth, — and to the organs of the chest and abdomen. Thirty-one pairs of spinal nerves pass out from the spinal cord through openings in the sides of the spinal canal. The spinal nerves are distributed to the trunk and the extremities of the body.

The nerves are for the purpose of carrying messages between the different parts of the body and the spinal cord and brain. The cell branches, as well as the matter composing the center of the cell, consist of transparent jellylike matter as clear as water, yet possessing the most wonderful properties of any known substance. By means of these living threads, which are many times smaller than the finest spider web, the nerve cells of the different parts of the body are in constant communication with one another, just as various points and cities of a country are in communication by means of telegraph and telephone wires. The brain is the central office which connects all the different parts. If the skin, bones, blood vessels, and muscles were removed, and nerve fibers and cells only were left, the outline of the body would still be complete. The feeling organs of the brain. the nerves, really occupy the whole body, just as do the circulating organs, the blood vessels.

How we feel and think



THIS DIAGRAM SHOWS THE STRUCTURE OF THE SPINAL CORD AND THE ORIGIN OF THE SPINAL NERVES.



HERE IS A VIEW OF A SECTION OF THE SPINAL CORD AND A SPINAL NERVE.

Experiments upon animals have shown that if a nerve going to any part is cut, the application of electricity to the outer portion of the nerve will cause the muscle to contract but will not cause any feeling; while if electricity is applied to the inner portion there will be no muscular contraction, but a feeling of pain. This experiment shows that nerve trunks are made up of two kinds of nerve fibers, one carrying impressions inward to the brain, and the other carrying impulses or commands outward to the muscles, or other organs.

Ingoing and outgoing nerves

The nerve fibers which carry impressions or sensations inwards are called *sensory nerves*, while those which carry commands or impulses outwards and cause all the different motions of the body, are called *motor nerves*. In the spinal nerves, the sensory and the motor fibers are generally bound together in the same bundle. Most of the cranial nerves are composed exclusively of either sensory or motor fibers.

Think of the different kinds of sensations that you experience and see how many you can enumerate. Besides the special senses, — hearing, seeing, smelling, tasting, and feeling, — we have what are called general sensations, such as fatigue, hunger, thirst. You will see that the sensory nerves are of many different kinds. For each kind of sensation, there is in the brain a special group of cells or a nerve center having charge of that particular sense, as you can see in the picture (p. 191).

The motor nerves, or nerves of work, are also connected with different groups of cells in the brain, each of which has charge of some particular organ or class of organs. The muscles, the stomach, the liver, the kidneys, and all other important organs have each their controlling centers.

It is not easy to comprehend the exact manner in which impressions are carried by the nerves. The best way, perhaps, is

to compare the process roughly to the action which passes along a row of bricks set on end in such a way that when a brick falls over it will strike the one next to it, which in turn will fall against the next, and so on to the end of the line. No matter how great the length of the line, the impulse given to the first brick will be sent through all the bricks to the last. If we imagine the line of bricks to be a nerve fiber, with one end in the skin and the other connected with a cell in the brain, we may get some idea of how an impression may be conducted along a nerve.

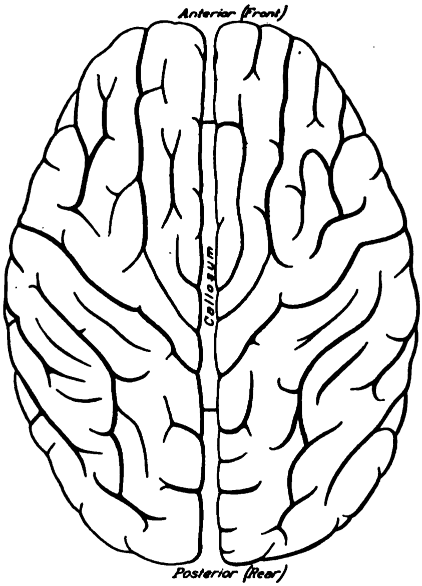
EVERY ORGAN IS UNDER THE CONTROL OF THE NERVOUS SYSTEM.

The cerebrum and its work

The large mass of nerve tissue which fills the upper part of the skull is called the *cerebrum*. It makes up three fourths of the entire brain and is sometimes called the *large brain*, to distinguish it from the *cerebellum*, which is sometimes called the *small brain*.

The cerebrum is divided into two hemispheres, the right and the left. The surface presents many furrows and folds, or convolutions. The outside is covered with layers of nerve cells, which give it a gray color. It is this gray material of the brain with which one's mental processes are chiefly associated. Underneath the gray matter the brain is white in appearance and is composed of the nerve fibers which connect with the cells. A network of fibers connects the different parts of the cerebrum, and countless fibers pass into the spinal cord.

The cerebrum is used in all our thinking. Through the nerve messages which come to it from all parts of the body, it receives the sensations of light, heat, sound, smell, taste, and others. It also sends out the messages that cause voluntary movement. Every part of the muscular system is connected with the brain; and each group of muscles has a corresponding group of cells by which it is controlled.



NOTICE THIS OUTLINE OF THE UPPER SURFACE OF THE CEREBRUM. NOTE THAT IT IS DIVIDED INTO TWO HEMISPHERES, THE RIGHT AND THE LEFT.

When the cerebrum is removed from the head of an animal, it does not die at once, but a remarkable change takes place in it. If it is a frog, it will swim when placed in water, and hop when pinched or stimulated in any way. In this respect it appears like any other frog. But it evidently has no intelligence. It is, in fact, quite idiotic. If made to hop, it will hop into the fire as readily as anywhere. If left alone, it will remain without stirring until it perishes. It has no power to issue commands to itself. It can perform only those reflex actions which require no intelligence but which are the response to some outside stimulus. Why can it perform such acts but not those requiring intelligence?

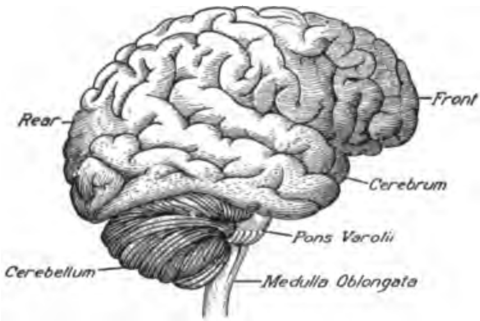
Disease of this part of the brain in human beings weakens the intelligence. It has been observed that the larger the cere-

brum in proportion to the rest of the brain, the greater the intelligence of the animal. It is proportionately much larger in man than in any other animal.

The cerebellum and its work

Beneath the back part of the cerebrum is the cerebellum, or little brain. It is similar in form to the cerebrum, and like it is divided into a right and a left half. It is also covered with a layer of nerve cells.

When the cerebellum is removed from birds or animals, they lose the power to make regulated movements. A man whose cerebellum is injured staggers about as though intoxicated. The movements are jerky and overdone. A person who is intoxicated cannot walk steadily, because of the paralyzing effect which alcohol has upon his cerebellum. So it seems that the chief office of the cerebellum is to regulate and coördinate the movements of the muscles, and to maintain the balance of the body by causing the muscles to act in harmony.



THIS SIDE VIEW (RIGHT) OF THE BRAIN SHOWS THE CEREBRUM, CEREBELLUM, AND MEDULLA OBLONGATA. THE CEREBRUM AND CEREBELLUM ARE COVERED WITH A LAYER OF NERVE CELLS.

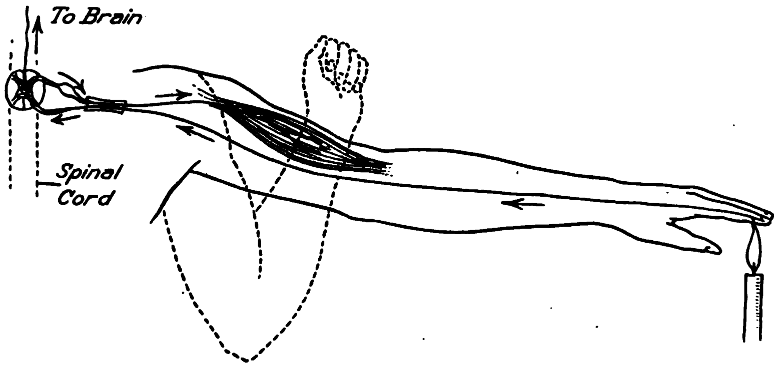
The medulla and its work

The *medulla* is an expansion of the upper end of the spinal cord. It contains many nerve fibers which connect the higher parts of the brain with the spinal cord and the body. It is a center for reflex and automatic actions, especially for those which are of the greatest importance to the body, such as the beating of the heart and the breathing.

We have seen that life may continue although the cerebrum or cerebellum are injured or even removed. But the mere puncture of the medulla with a needle is sufficient to cause death, because it stops the breathing. For this reason the medulla has been called the "vital knot."

Reflex action

When the hand comes in contact with a hot object, it is instantly drawn away. One does not have to say to himself, "My hand is likely to be burned, so I had better draw it away." The hand is pulled away before there has been time for thought. In a little baby with no power to reason the hand would instantly be pulled away from a candle flame.



WHEN A CHILD'S HAND TOUCHES A LIGHTED CANDLE THE INCARRYING OR SENSORY NERVES CONVEY THE IMPRESSION INSTANTLY TO THE SPINAL CORD, AND THE OUTCARRYING OR MOTOR NERVES INSTANTLY CONVEY AN IMPULSE TO THE MUSCLES OF THE ARM TO WITHDRAW THE HAND. THIS IS REFLEX ACTION.

When a sensation gives rise to motion in this way, the action is called *reflex*. Reflex actions are of immense importance in protecting the body from injuries of various sorts. The acts of winking, swallowing, sneezing, coughing, and vomiting are all reflex. These are helpful acts; and the impulse to perform them may be so violent that it cannot be suppressed by the will. Sneezing, for example, is for the purpose of discharging some

offending object from the nose; coughing for removing some object from the air passages; vomiting to empty the stomach of something that needs to be expelled. The closing of the eyelid when the eye is touched is another example of reflex action. The internal organs are controlled almost entirely by such action.

The spinal cord and its work

The work of the spinal cord is the same as that of the medulla. It is the passage through which impulses are conducted to and from the brain. It is also the center for reflex actions. When the spinal cord is cut across or severely injured, all parts of the body below the injury are paralyzed, and lose their feeling, because they have lost their connection with the cerebrum, the seat of feeling and of action. But reflex actions are still possible. For instance, a hot iron applied to the foot will produce no pain, even though the foot may be severely burned. But if the sole of the foot is tickled, it will be jerked away by a strong contraction of the muscles, although the person may not even know that his foot has moved. The feet of a person who is sound asleep will move in the same manner when tickled. This shows clearly that the spinal cord without the aid of the brain can carry on reflex actions for those parts of the body that are reached by the spinal nerves. For this reason a frog without a head may be made to hop, or a headless turtle to walk about. These acts are governed by the spinal cord.

Acquired reflexes

Besides these natural reflex actions requiring no intelligence, there are what are called *acquired reflexes*. Take the act of walking, for example. When a child first attempts to walk, a voluntary effort is required each time the foot is moved and put forward. After a while he can walk a long distance without thinking about it or giving any attention to the feet. The mind may be wholly occupied with something else. The action has then become reflex; it is

performed without any effort of the mind. This is true only when one walks at his usual pace. If you try to walk much slower or much faster than usual, you will find that you have to make a conscious effort to do so.

Writing is at first a laborious act which requires very close and constant effort to direct the muscles employed. But the accomplished penman is able to write rapidly without seeming to give any thought to the formation of the letters. He thinks of the word he wishes to write and his hand produces it. In swimming, bicycle riding, and many other performances, the necessary movements are made without thought, after the nerves involved in them have been trained by practice. Without this provision it would not be possible to become very skillful in any art or trade.

At the base of the large brain or cerebrum are some very interesting groups of cells which serve as middlemen. They receive orders from the large brain and transmit them through the spinal cord to the organs for which they are intended. The control of those acts which are performed very frequently is for the most part transferred from the cerebrum to these centers. They may be called the servants of the cerebrum, since they are always ready to carry out its orders and at last become so well trained that they can do some kinds of work without supervision of the higher centers. In this way the cerebrum is relieved from much labor and drudgery and left free for higher kinds of work.

How habits are formed

Each time an act is repeated it is done with a little greater ease. After a time it is done without any effort of the mind. Then it has become a habit. "Sow an act and reap a habit; sow a habit and reap a character." Every act of importance not only originates in the brain, but makes an impression upon it. It is in this way that our

characters are built. The character is largely formed by our habits. Perhaps we may say that our character is the sum of all our habits, and our habits are formed by constantly repeated actions.

One of the most wonderful of the abilities of the mind is memory. How are sight pictures and sound pictures stored in the mind, and how are we able to recall them? In some way impressions made through the eye, the ear, and the other senses cause such actions and changes in the nerve cells that they are able under the right sort of conditions to call back the impressions they have received.

How we remember

In order for a thing to be remembered it is necessary that *the first impression shall be clear and strong*. Whether an impression lasts or not depends mainly upon how clear it is. For this it is necessary that *the attention should be concentrated* while the thing is being learned. Good attention is the first essential of a good memory. The more active the mind is in regard to any impression when it is being made, the longer the impression is likely to be retained.

Exercise is quite as necessary for the health of the brain and the nerves as for the rest of the body. Mental strength and capacity are developed by mental work, just as the muscles are developed by muscular work. So, too the brain may be injured by overstudy, just as the muscles may be hurt by overstrain.

When the brain is weary, impressions made upon it are slight and soon become indistinct. For this reason it is better to spend only two or three hours at a time in hard study. A short period of exercise, especially if taken in the open air, will refresh the brain and make it active and ready to receive new impressions.

Muscular exercise is of great benefit to brain workers. We have seen how exercise keeps the stream of life fresh and pure and washes away the poisonous products that tend to clog the

mental machinery. Students and professional men break down much more often through neglecting to take muscular exercise than through doing too much mental work.

Plenty of fresh air and good food are needed for the support of the brain and nerves, just as for the rest of the body. Eating too much or living on unwholesome or indigestible food clogs and hinders the brain in its work. Clear thinking and a good memory can go on only in a healthy and unclouded brain. Overeating and indigestion are especially likely to weaken the memory and to produce a state of mental confusion, lack of power to concentrate the mind, and inability to decide questions.

An abundance of sound sleep is necessary for the health of the nervous system. During perfectly sound sleep, the brain is wholly inactive; the spaces about the nerve cells become filled with lymph, and the parts worn by use undergo repair. During the activity of the day there is little opportunity for the repair of brain tissue. This work is done almost wholly during sleep. At least seven or eight hours of sleep are required each night by grown people. Young people who are still growing require more than older persons.

During unsound sleep the brain is partly active but in an irregular way. Confused pictures present themselves. The result is dreaming. When one constantly dreams at night of the work he has been doing, it is an indication that those parts of the brain used during the day are not being properly rested and restored at night. They are in danger of becoming diseased. A vacation or change of occupation is then necessary. Sleeplessness is often caused by eating late in the evening. The best way to secure sound sleep is to take only ripe fruit or other very easily digested food for the evening meal. Tea, coffee, and chocolate tend to produce sleeplessness.

Fatigue caused by out-of-door exercise has a good effect in

bringing sleep. A prolonged bath, of from fifteen to twenty minutes, at a temperature of 96 to 98 degrees, taken just before going to bed, is an excellent remedy for sleeplessness.

Failure to eliminate the waste matters from the body regularly is one of the most common causes of nervousness and sleeplessness. It is also perhaps the most common of all causes of exhaustion and chronic fatigue. The poisons produced in the colon by the putrefaction of food residues have been shown to be potent in causing fatigue. These poisons, when extracted from the colon contents and applied to the tissues of animals, were found to produce all the evidences of chronic fatigue. To keep the brain and nerves in a healthy condition, the colon should be kept free from putrefying food wastes.

Nerve poisons

We have already noted that alcohol paralyzes the nerve cells that control movements, causing a staggering walk and falling. Alcohol also makes a man temporarily insane, by paralyzing certain of the nerve cells so that the brain is unable to make correct judgments. Peculiar and unnatural combinations of ideas are made, often with terrible results. A man who is naturally peaceable may while under the influence of alcohol become violent, destructive, and ferocious. In the disease caused by alcohol, called *delirium tremens*, the drunkard's ideas become curiously mixed. The sufferer sees snakes, reptiles, and all sorts of monsters and strange shapes before him.

The ill effects of tobacco upon the nervous system have been pointed out by many eminent physicians. Here are some of the things they say about it:

"Giddiness is a common effect of excessive tobacco smoking. Tremor is one of the commonest. It may be cured entirely by abandoning the use of tobacco."

"Sleeplessness is one of the most common effects of tobacco smoking."

It has been shown that tobacco poison affects the auditory nerve and so causes defective hearing or deafness.

"The use of cigarettes has an evil effect upon the mucous membrane lining of the nose and throat, and as these organs are closely connected with the organ of hearing, anything that affects them is likely to react upon the hearing."

Tobacco also affects the optic nerve, weakening the power of color perception, and injuring the sight in other ways. This is recognized in every trade or profession that requires quick and accurate sight.

A certain railway company issued the following notice to employees: "*For the betterment of the service* and *the safety of the public* it will from this date be the policy of this company NOT to retain in its employ men who use intoxicating liquors or cigarettes."

Tobacco has also a harmful effect upon the mental efficiency of young smokers. Out of 2336 cigarette smokers who were attending public school, only six were reported as "bright pupils." A very few were "average." All the rest were "poor" or "worthless" pupils.

Its effects upon the moral nature are also marked. A physician who has had the best opportunities for seeing the effects of tobacco upon the morals says he is convinced, from much observation, that the poisonous gases from tobacco stupefy the nerve centers that control the moral sensibilities, so that the fine edge of the moral nature is blunted and the smoker's sense of the difference between right and wrong is blurred.

Health Problems

1. Suppose you should cut a nerve leading to the end of your finger and that you could keep it from healing, what would happen to your finger? Why?

2. Does nature take special pains to keep the brain from becoming injured? If you think so, give reasons.

3. Why does man, like most other animals, have a long spinal column?

4. Show just how a command gets from your brain down to the last joint in your finger so that you can move it. How does a command travel down to your big toe so that you can move it?

5. Think of a good way to show that there is a special group of cells in the brain that has to do with vision; another group that has to do with hearing; another group that controls the right hand, and so on.

6. Mention a number of reflex actions which are not spoken of in the text. Can you mention any harmful reflex actions? If so, how can one control them so that they will not get him into trouble?

7. Mention at least five habits that you possess which are not mentioned in the text. Why is it proper to speak of one's character as "the sum of his habits"?

8. Can you close your eyes and visualize clearly your father, mother, brothers, and sisters? Can you image your breakfast table so that you can describe the dishes, the people who sat around the table, and so on?

9. Can you now hear the voices of your father, mother, brothers, and sisters even though they are absent?

10. Take something you have forgotten in literature, arithmetic, spelling, or any other subject, and see if you can tell why you have not remembered it. What could you have done so that it would have remained with you?

11. Have you ever tried taking exercise when you could not learn your school lessons rapidly? Did it clear your mind? Explain.

12. What has happened in the nervous system of the person who is drunk? Suppose the alcohol remained in his system permanently, what would become of him?

Review Questions

1. What is the source of the commands that set the digestive organs at work? That make the lungs work faster when necessary?

2. What are the two kinds of nervous tissue?

3. Describe the nerve cell. Of what use are the buds on the branches of nerve cells?

4. What is a nerve center, or ganglion?

5. What are the bundles of nerve fibers called?

6. What are the two divisions of the nervous system?

7. What is the "headquarters," as one might say, of the nervous system?

8. How does the spinal cord connect with the brain? Describe this cord in detail, and explain its relation to the rest of the nervous system.

9. What are the nerves that convey impressions from the senses to the brain called? Those that carry commands from the brain to the muscles?

10. Show how impressions are conducted from the brain to the muscles.

11. What is a reflex action? What is its use? Name some reflex actions which may occur during sleep.

12. What name is given to the large brain? The small brain?

13. With what is the outside of the brain covered?

14. What part of the brain do we use in our thinking?

15. What happens to a frog when its cerebrum is removed? What does this show regarding the work of the cerebrum?

16. When the cerebellum is removed from birds and animals, what happens to them?

17. Where is the medulla situated? What work does it have to perform?

18. What is the work of the spinal cord?

19. Why can reflex actions occur when a person is without consciousness?

20. How is it possible for a frog without a head to hop?

21. How does one form habits? What is the relation between habits and character?

22. How is it possible for one to retain the memory of any experience he has had?

23. Why is it difficult to recall things when one is weary?

24. How can one cultivate a good memory?

25. Is exercise necessary for the health of the brain and nerves?

26. Why should one not study when he is fatigued? What kind of exercise is good for brain workers? Why?

27. What sorts of habits will prevent one's thinking clearly?

28. Is sleep necessary for the health of the nervous system? What is a good way to overcome sleeplessness?

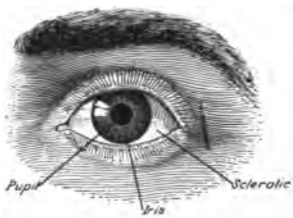
29. Why does one dream? What kinds of habit will be likely to make one dream a good deal?

30. Mention some nerve poisons and their effect on the brain.

CHAPTER XV

Gateways of the Mind — Sight

The brain has only one way of getting information from the outside world. This is by means of sensations received through the nervous system. There are two kinds of sensations: (1) Those which arise from conditions within the body, such as fatigue, drowsiness, pain, hunger, and thirst. These are called *general sensations*. (2) Those which are caused by some stimulus from outside, as sight, hearing, smell, taste, and touch, by means of which we get a knowledge of objects in the world about us. These are called the *special senses*. They are the avenues or gateways to the mind. The information brought to the brain through them is the food of the mind, or thought material.



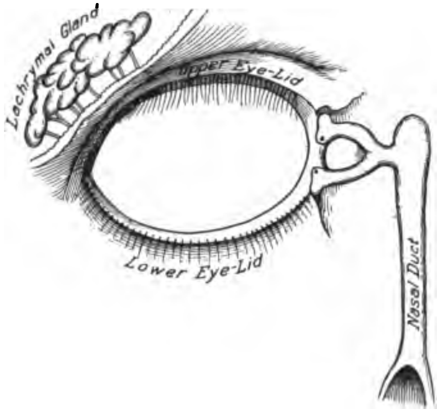
The eye is a picture-making instrument, much more wonderfully and perfectly made than the photographer's camera.

The eye, the body's camera

Perhaps the most remarkable of these avenues to the brain is the eye. The eye is a picture-making instrument, very much like a photographer's camera, only much more wonderfully and perfectly made. The eye of an ox recently killed may be prepared in such a way that one can clearly see the picture formed by the lens of the eye on the dark curtain stretched across the back of the eye globe. In some mysterious way, by means of a special nerve, the *optic*

nerve, which connects the eye with the brain, a record is made of this picture in the cells of the brain.

One looks at an object, — the face of a friend, a beautiful flower, a strange animal, a collision of vehicles in the street. The next day, or it may be years after, the picture may be reproduced in the mind, showing that a record has been made in the brain. A famous artist once produced from memory a copy of a picture hanging in a gallery in a distant city. The copy was so like the original that it was difficult to distinguish one from the other. This reproducing of original impressions is what the brain is doing all the time for every one whose brain and eyes and optic nerves are healthy.



THE LACHRYMAL GLAND PRODUCES A SECRETION WHICH MOISTENS THE EYE. WHEN THIS SECRETION IS PRODUCED IN TOO LARGE A QUANTITY TO BE DRAINED OFF THROUGH THE LITTLE CANALS PROVIDED FOR THE PURPOSE, IT FLOWS OVER THE EYELIDS IN TEARS.

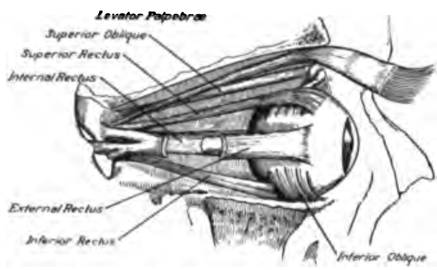
The protection of the eye

The eyes are well protected by nature. They are set in deep bony sockets in the skull, open in front. At the back part there is an opening through which pass the nerves which connect the eye with the brain. The eye socket is lined with fat, which forms a soft cushion for the eye to rest and turn on, and helps to protect it from injury.

The eyelids, eyelashes, and eyebrows also assist in protecting the eyes from injury. The eyelids protect the eye from too much light and, by quickly closing and covering the exposed part of the eyeball, they shield it from any threatening blow.

Along the edge of the eyelids may be seen the openings of numerous little glands which pour out an oily substance that prevents the ordinary moisture of the eye from overflowing. The eyelashes, with which the edges of the lids are also furnished, keep dust out of the eyes.

The little gland that produces moisture, the *lachrymal gland*, is within the socket of the eye, at the outer and upper side. Here a secretion is constantly formed in small quantities for the purpose of moistening the eyes. This secretion is drained away by means of two little canals, one at the edge of each lid, at the inner corner of the eye. These little canals open into a small sac from which the tears are carried into the nose, through a duct called the *nasal duct*. When the secretion from the lachrymal gland is formed in too great quantity to be carried off in this way, the tears flow over the lids and run down the cheeks.



EACH EYE IS PROVIDED WITH SIX LITTLE MUSCLES BY MEANS OF WHICH IT CAN BE TURNED IN EVERY DIRECTION.

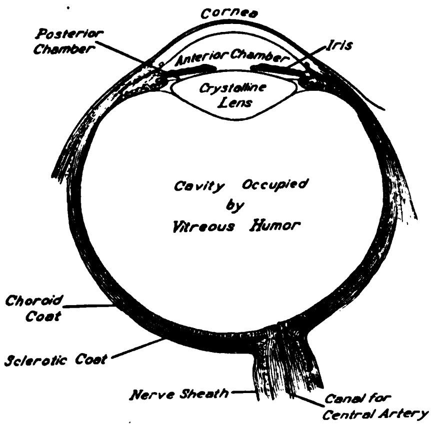
Each eye is provided with six little muscles. One end of each of these is attached to the socket and the other to the eyeball. By this means the eye may be turned in various directions. Think what would be the effect if it were not possible to move the eyeball!

The parts of the eye and their uses

The eyeball has three layers or coats: the outer coat, or *sclerotic;* the middle coat, or *choroid;* the inner coat, or *retina*. The sclerotic is formed of a dense white membrane, — the white of the eye, as we call it. In its front part is a transparent portion called the *cornea*, which lets the light

through into the eye, just as a window lets the light into a room.

Next to the sclerotic and in close contact with it is the choroid, which is of a rich, purple color. In the front of the choroid, just at the back of the transparent cornea, is the *iris*, a movable, muscular curtain lined with dark pigment. The iris is the colored part of the eye, blue, brown, gray, or black, which we see through the transparent cornea. It has an opening in the center called the *pupil*.



THIS PICTURES A SECTION OF THE EYE SHOWING THE DIFFERENT PARTS AND CHAMBERS.

The iris regulates the amount of light that enters the eye. When the light is dim, the opening is enlarged to let in as much light as possible. When the light is strong, the pupil is made very small to protect the eye. You have seen the pupils in the eyes of a cat in the sunlight reduced to mere slits, while on the contrary the pupils in the eyes of a cat that has been in the dark are so enlarged that the iris can scarcely be seen. The pupils of the eyes of cats and of certain other animals can be opened wider than the pupils of human eyes, and for this reason such animals can see in the dark better than we can.

The retina, the inner coat of the eyeball, contains the nerves of sight. It is formed by the spreading out of the optic nerve, which enters the eyeball at the back, nearly opposite the pupil. It is composed of several layers of different kinds of cells, which

are connected with the ends of the fibers of the optic nerve. In this way it is connected with the nerve centers in the brain that preside over the sense of sight. The layer of cells next to the choroid or middle coat has a purple color. The color fades when the retina is exposed to light, but is constantly reproduced by the choroid.

Just at the back of the iris is the *crystalline lens*, which divides the inside of the eye into two chambers. The large chamber at the back of the lens, called the *posterior chamber*, forms the greater part of the cavity of the eyeball. It is filled by a transparent, jellylike substance called *vitreous humor*. The small chamber in the front of the lens, called the *anterior chamber*, is filled with *aqueous humor*, a watery fluid which runs out when the eyeball is pierced with a sharp instrument.

How the eye forms images and retains them

The lens, aided by the convex surface of the cornea, forms images of the objects that we see. An image formed by a lens in the front of a camera may be seen upon the ground glass at the back of the camera. If we hold a convex lens before a window and at the proper distance from a screen of thin oiled paper or ground glass, we may see upon the screen a perfect picture of the window, but much smaller than the original. The lens and the cornea of the eye form images upon the retina in the same way that the image is formed on the screen or camera.

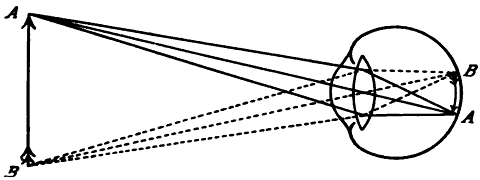
Many colored fabrics fade or lose their color when long exposed to the sun's rays. Muslin may be bleached or made white by exposure to the sun. When the retina taken from the eye of an animal is exposed to the sun, the color is bleached out in the same way. But if it is left in contact with the choroid, and is placed in the dark, it will soon recover its color.

If we allow the image formed by a lens to fall upon the retina taken from the eye of an animal, the picture will be bleached

upon the retina by the action of the sun's rays. This is exactly what happens when we see an object. The lens of the eye, assisted by the cornea, forms an image which is bleached upon the retina in the way described. The impression made upon the retina is carried to the brain by means of the optic nerve.

Impressions made upon the retina may last after the object making the impression is removed. A thing may be looked at for only the hundredth part of a second, yet it will take a whole tenth of a second for the image formed to die away. You can see that if a second picture is presented before the first has died away, the pictures will blend. The effect is then the same as if both objects were seen at the same time.

A toy has been made to illustrate this. It consists of a piece of white card with two strings upon which it can be so twirled that first one side is shown, then the other. On each side of the card a different picture is painted. Suppose, for instance, that on one side of the card is a lion and on the other his cage. When the card is rapidly twirled by being blown upon, the lion will be seen in his cage. Or it may be a horse on one side and his rider on the other. Twirling the card rapidly will have the effect of seating the rider upon his horse. Explain the principle.



THIS DIAGRAM SHOWS HOW REVERSED IMAGES ARE FORMED UPON THE RETINA OF THE EYE. WHY IS IT THAT WE DO NOT SEE THINGS UPSIDE DOWN?

If you examine carefully the image made by a lens you will see that the picture is inverted. The two sides are also reversed. This is because the rays of light cross each other in passing through a lens. Why is it that though the picture in the eye is upside down, yet we seem to see the object right side up?

Do you think a very young infant sees things right side up as we do?

By experimenting with a lens held at a certain distance from a screen, you will see that the images of near and of distant objects are not equally perfect. In order to get good pictures of all objects, you must either change the position of the lens, or use a thicker lens for near objects and a thinner one for distant objects. The position of the lens in the eye cannot be changed. It is fixed at a certain distance from the retina. Neither can it be exchanged for a thicker or thinner one, according to the object to be looked at. But Nature has provided a means by which the lens may be made thicker or thinner and so may adjust itself perfectly to see objects at different distances. This is done by means of the muscular ring surrounding the lens, — the *suspensory ligament*. This work of adjusting the lens is called *accommodation*. The eye seems to see without effort objects at a distance, and accommodation is exercised only for near objects. A perfectly natural eye cannot adjust itself to see objects nearer than five to eight inches.

Seeing near and far objects

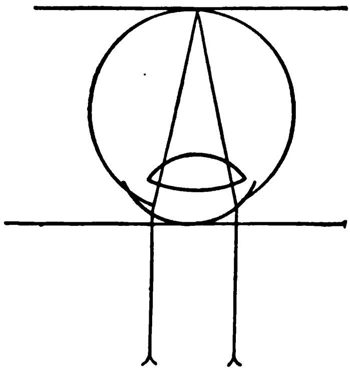
OBSERVE CHANGES IN THE LENS IN ACCOMMODATION.

In reading or doing any kind of close work, the muscles of the suspensory ligament are contracted to thicken the lens and so adjust it for seeing near objects. If the work is long continued, it is a good thing to relax these muscles and rest the eyes by occasionally gazing out of a window into the distance.

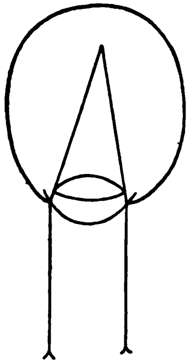
Two kinds of sight

In some persons the eyeballs are long from the front to the back, so that the retina is farther than usual from the lens. Here is a little experiment which will help you to understand what effect this extra length has upon the sight.

Take a lens which will make upon a screen held a few inches behind it a distinct image of distant objects. If the screen be moved farther from the lens the image of the objects will



THE NORMAL EYE. THE EYEBALL IS JUST THE RIGHT LENGTH AND THE LENS HAS JUST THE RIGHT DEGREE OF CURVATURE SO THAT THE RAYS OF LIGHT ARE FOCUSED PRECISELY UPON THE RETINA.



THE NEARSIGHTED EYE. THE EYEBALL IS TOO LONG SO THAT THE RAYS OF LIGHT FOCUS IN FRONT OF THE RETINA.

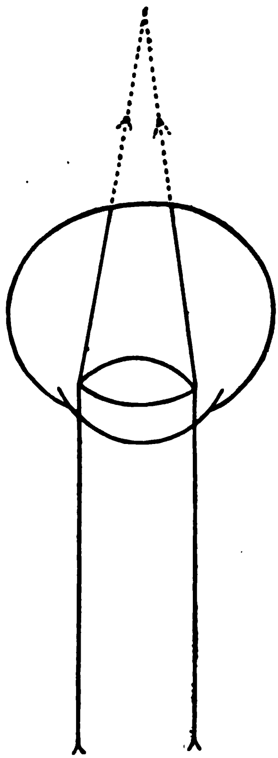
become indistinct. But if the objects are brought nearer the lens, a clear image of them will again be formed upon the screen. This shows us that if the retina of an eye should happen to be farther from the lens than it ought to be, distant objects would not be seen clearly, although near objects might be seen distinctly. A person having such eyes is said to be *near-sighted.*

In other cases the eyeball is shorter than usual, so that the retina is brought too near the lens. In these cases distant objects may be clearly seen, while near objects are blurred or indistinct. Such eyes are called *farsighted.*

If you watch an elderly person trying to read without glasses, you will notice that usually the book is held a long way from the eyes. The reason for this is that at about the age of forty-five

years the lens begins to harden, so that it cannot be accurately adjusted to near objects.

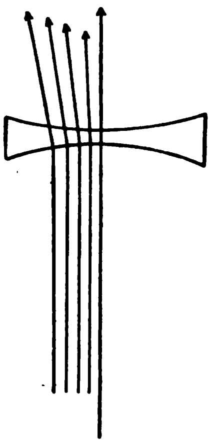
In some cases the curvature of the cornea is uneven and some parts are flatter than other parts. When this irregularity is enough to distort the image so that objects are not seen clearly, it is called *astigmatism*. This is a very common eye defect and is often combined with nearsightedness or farsightedness.



THE FARSIGHTED EYE. THE EYEBALL IS TOO SHORT AND THE RAYS OF LIGHT FOCUS BACK OF THE RETINA.

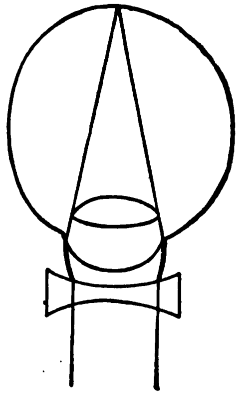
Wearing glasses

Nearsighted, farsighted, and most old persons need the assistance of glasses which will cause the image to fall exactly on the retina, so that the object may be distinctly seen. For a nearsighted eye, on which the rays of light meet before they reach the retina, concave lenses are needed to spread the rays of light farther apart. Farsighted eyes in which the rays reach the retina before they meet, need convex lenses, which will bend the rays of light toward each other, and cause them to meet more quickly. Old persons



THE DOUBLE CONCAVE LENS. NOTICE THAT IT SPREADS THE RAYS OF LIGHT AND SO CAN BE USED TO CORRECT A NEARSIGHTED DEFECT, AS SHOWN IN THE FOLLOWING ILLUSTRATION.

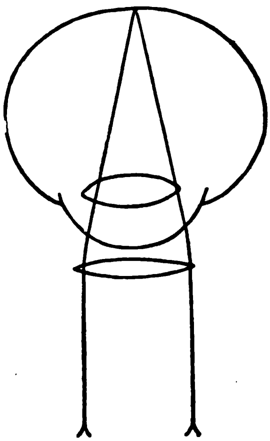
need convex lenses which should be changed as age increases. When an old person finds himself obliged to pull his glasses down on his nose in order to see clearly, it is a sign that he needs lenses that are more convex.



THE ONLY WAY TO CORRECT NEARSIGHTEDNESS, — USING A CONCAVE LENS SO THAT THE RAYS OF LIGHT WILL FOCUS EXACTLY ON THE RETINA.

With what do we really see?

The eye is the organ of sight, but it is with the brain that we actually see. If the optic nerve is cut, pictures will still be formed in the eye but there will be no sight. It is with the brain that we form judgments of the images transmitted through the eye, as to their distance, shape, position, solidity. The nerve centers controlling sight have to be trained by practice to form accurate judgments. A little baby reaches out for everything it sees, no matter how far away, and experiments have shown that not until it is several months old does it have a definite idea of distance. Why?



THE ONLY WAY TO CORRECT FARSIGHTEDNESS, — USING A CONVEX LENS, SO AS TO FOCUS THE RAYS OF LIGHT ON THE RETINA.

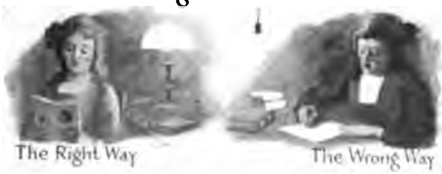
A young Scotchman who was born blind received his sight when he was thirty years old by means of an operation. He at first thought that everything he saw was quite close to him. The first day that he sat near a window, he put out his hand to touch the sidewalk, which was two stories below. He said, "The first meal I ate was an odd experience. When I saw that great hand

(1)

CARE OF THE EYES

Only one pair of eyes for life!

Dangers at Home



AVOID
- Facing the light
- Reading in the twilight
- Reading when lying on the back
- Using the "common" towel

Dangers at School

When the eyes water, blur or ache, or the school doctor reports defect, consult an oculist. Headaches, indigestion, and other troubles may be due to defective eyes.

with a huge fork approaching my mouth, the impulse to dodge was almost irresistible." Explain this man's experience.

The eyes are such a precious possession that they need to be guarded carefully. Think from how much one is shut out who does not have the use of these wonderful organs that reveal all the beautiful and interesting things in the world around him.

The care of the eyes

Carelessness in the use of the eyes while one is young may cause a great deal of trouble and even blindness later in life. It is important to avoid straining the eyes. This is most likely to occur in reading. When one is interested in a book, it is sometimes a temptation to go on reading into the twilight. Reading in a poor light is a great strain on the eyesight. Why? Reading very fine print for a long time without resting the eyes also strains them. Why?

Reading on the cars is likely to be injurious to the eyes, because of the shaking which continually changes the distance between the book and the eye. You can see what a tax this is upon the muscles of accommodation, which must keep adjusting the eye to the changed distance.

Reading while lying down is a bad practice. In this position too much blood comes to the eyes, which are likely to become congested. The book is also likely to be held in an awkward position in relation to the eyes.

It is not a good thing to read when first awaking in the morning, as it takes a little while for the eyes to become accustomed to the light. Sudden exposure of the eyes to very bright light may be injurious for the same reason.

The direction in which the light falls is of very great importance to the eyes in such occupations as reading, writing, and needlework. The light should shine upon the work, not upon the eyes. You may find out for yourself the best position for

doing near work of any kind by trying a few experiments. Sit or stand with your back to a window while you read. You will see that your shadow falls upon the page and darkens it. Face the window, and you will see that this is even more unsatisfactory. The light shines directly into the eyes, while the book is in shadow. Sit with your right side to the window and you will find a great improvement. The light now falls directly upon the page and not upon the eyes. But try writing in this

IT IS OF THE GREATEST IMPORTANCE TO HAVE A SCHOOLROOM WELL LIGHTED, SO THAT THERE WILL NOT BE TOO STRONG LIGHT IN SOME PARTS OF THE ROOM AND TOO WEAK LIGHT IN OTHER PARTS. THIS ROOM IS EVENLY LIGHTED THROUGHOUT.

position. The hand then casts a shadow upon the paper which will obscure the light just where it is most needed. Sit now with your left side to the window, and you will find that the light is just right for all purposes.

Notice where the windows in your schoolroom are placed and how the light falls upon your desk. Is it a good thing for the teacher's desk to be placed in front of a window? Which is the best position for the blackboards, between the windows or facing them?

Severe headaches, indigestion, and other nervous troubles may be caused by defective eyesight. People very often think their digestion is out of order when they really need glasses. If the eyes become easily tired and can be used but a short time

EVERY SCHOOL BUILDING SHOULD BE EQUIPPED WITH FACILITIES FOR THE MEDICAL EXAMINATION OF PUPILS. IT IS ESPECIALLY IMPORTANT THAT PUPILS SHOULD HAVE THEIR EYES TESTED AT REGULAR INTERVALS.

without blurring the vision or causing the eyeballs to ache, they should be examined by a specialist, and if possible, properly fitted with glasses. It has been found that from thirty to sixty out of every one hundred children in the public schools should wear glasses.

The corners of the eyes should be kept clean, and the lids washed carefully. A disease which causes very great soreness and inflammation of the lids is due to germs which breed inside the lining of the eyelids. It is not safe to use public washbasins or towels, because of the danger of getting the eyes infected with these germs. Children suffering from this disease are not allowed to attend the public schools, because of the danger of infecting other children.

At home as well as at school and wherever the person is who has a communicable eye disease, the greatest care should be taken that the germs of disease are not scattered.

If sore eyes are carelessly rubbed, germs are certain to get on the hands. If before washing the hands, the patient uses books, toys, or other things, some of the germs are likely to be left on these articles. Other persons using these things get germs on their hands. If one of these persons rubs his eyes with unwashed hands, the circuit from diseased eyes to well ones will be completed and the seed will be planted for another case of eye trouble. One can hardly expect to prevent germs from getting on the hands, since whatever objects large numbers of people handle, such as door knobs, stair railings, car straps, and school books, are likely to carry them. But one can prevent their being introduced into the eyes, if he heeds this most important rule: *Never rub the eyes with unwashed hands.*

As mentioned before, Nature has made careful provision to protect the eyes from dust, for dust is very injurious to them. It irritates the lining of the eyelids, scratches the surface of the eye, and may carry the germs that cause inflammation. If a speck of dust, a cinder, or some substance gets into the eye, *do not rub it*, as this may cause the particle to become embedded in the lining or in the surface of the eye. Carefully draw the upper lid over the lower. In many cases this will remove the

particle. Or holding up the eyelid and moving the eye about may remove it. It may sometimes be washed out by bathing the eye.

Eminent English eye specialists have recently called attention to the fact that auto-intoxication, or general poisoning of the body, which results from lack of elimination of waste matters, often causes serious injury to the delicate structures of the eye. The eyes naturally deteriorate with advancing age, but not infrequently a person of twenty who is careless in regard to elimination, will be found to have an impairment of the eyes equal to that usually found in a person fifty or sixty years of age. This sort of eye impairment is due to poisoning from wastes retained in the body and quickly disappears when the cause is removed.

Health Problems

1. Can you give any estimate of the number of pictures that are recorded in your brain?

2. Why do you think the nose has been made so prominent, while the eyes have been set back in sockets?

3. Mention the different movements that can be made by the eye. Is each movement of service to us? How?

4. Make a drawing which will show what a concave shape is. Make one that will show a convex shape. What is a good device to use in distinguishing between a convex and a concave shape?

5. Can you suggest a good test other than the one mentioned in the text to show that an image lasts after the object from which it is gained is removed?

6. Hold the pages of this book before a mirror. What do you notice regarding inversion and reversal of images? Is the same thing true of our features when we look at them in a mirror?

7. How near to the eye can you put a small object and see it? Why can you not see it when it is brought nearer? Most people after the age of fifty wear what is known as bifocal lenses; that is, one part of the lens is a little differently shaped from the other part. One part is used for reading

and close work, the other part for looking at objects, farther away. Why do not young people have to wear glasses like this?

8. Show by a drawing why concave lenses are worn by nearsighted people, and convex lenses by farsighted people.

9. Suggest an experiment which will illustrate some of the ways in which people fatigue their eyes.

Review Questions

1. Why is it proper to speak of the senses as the gateways of the mind?
2. Which is the most remarkable of the gateways of the mind?
3. How do impressions get from the back of the eyeball to the brain?
4. How do we know that a record is made in the brain when we look at an object?
5. How are pictures made on the retina?
6. How do the eyelids, eyelashes, and eyebrows help to protect the eye from injury?
7. What is Nature's provision for preventing the overflow of moisture of the eye? How are the tears drained away?
8. What is the name of the gland in which the tears are formed? Where is it situated?
9. How many muscles are provided for each eye? How are these attached to the eye?
10. What is the outer coat of the eye called? The middle coat? The inner coat?
11. How is the sclerotic coat formed?
12. What is the cornea? Where is it located, and what is its work?
13. Where is the choroid situated? What work does it have to do? Where is the iris, and what is its work?
14. Where is the pupil of the eye?
15. Where is the crystalline lens, and what is its office in the eye?
16. What is a convex lens?
17. Describe the toy which is designed to show that an image of an object lasts a little time after the object disappears.
18. Why is it that an image on the retina is inverted and the sides reversed?
19. What happens to the image when the distance of the object at which one is looking is changed?

20. What happens to the lens when the amount of light entering the eye is increased or decreased?

21. How is it possible for the lens to become thicker or thinner?

22. What sort of work may fatigue the muscles controlling the lens?

23. What causes nearsightedness? What causes farsightedness?

24. What kind of glasses must a nearsighted person wear? What sort should be worn by a farsighted person?

25. Describe the care that should be taken of the eyes in reading.

26. From what side should the light fall upon any work we are doing?

27. What troubles are likely to come from defective eyesight?

28. What care should be taken to protect the eyes from dust and the like?

CHAPTER XVI

Gateways of the Mind — Hearing

Each special sense organ gives us peculiar sensations which cannot be given by any other organ. The eye gives sensations of light, and the ear sensations of sound. A little experiment will help to make clear to us what it is that causes the sensation of sound. Rest one end of a board upon a table, holding it in position with the left hand. Then draw a pin across the board with the right hand, and you will notice that the board trembles or vibrates. If you now press your head against the upper end of the board and draw the pin across it again, a loud sound will be heard. The vibrations of the board will be communicated through the ear to the nerves of hearing. We can hear the scratching of the pin, even though we do not place the ear against the board, because the vibrations of the board start vibrations in the surrounding air and these sound waves are brought to the ear. When the string of a violin or harp is made to "sound," you can see that it is in rapid vibration, and the same thing takes place in all sounding bodies.

You can get some idea of how sound travels by another simple experiment. Throw a stone into the calm water of a pond. You will see that a little ring of waves forms itself at the point where the stone struck the water, and that these waves travel in all directions, as far as the water extends. If a piece of wood is made to float upon the water, it will bob up and down as the wave reaches it, being set in motion by the movement that was

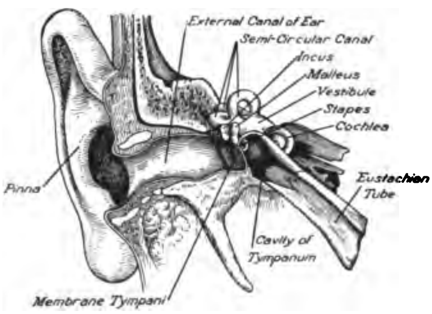
started in the water by the stone. *Sound waves* are made in the air by the vibration of sounding bodies in somewhat the same way that the waves are made in the water by the falling stone. These sound waves traveling through the air reach the inner ear and set its movable parts in motion, as the wave in the water sets the piece of wood in motion.

We see, then, that sound is the impression produced on us when the vibrations of the air strike on the drum of the ear.

How we hear

When the vibrations are few, the sound is deep and low; and when they increase in number, it becomes shriller and higher. The lowest sound that can be heard by the human ear is made by about sixteen vibrations in a second. When the number reaches 40,000 in a second, the sound cannot be heard by the human ear.

Think what a great variety of air movements there must be in order to cause all the kinds of noises we hear. Yet all these can be received by the ear and sent to the brain; and each keeps its own peculiar quality. So sensitive is the ear that we can at once recognize a familiar voice, even though we do not see the face of the speaker. Let us take a look inside the ear and examine the wonderful mechanism by which the work of hearing is done.



BY MEANS OF THIS WONDERFUL MECHANISM WE ARE ABLE TO HEAR. SEE IF YOU CAN TELL WHAT EACH PART OF THE MECHANISM DOES TO ENABLE US TO HEAR.

(1) What is called the *outer ear* is (*a*) the part that we can see, and that we commonly speak of as "the ear," and (*b*) the *auditory canal* or tube through which the vibrations

pass to the ***drum***. The ear that we see is placed where it is for the purpose of gathering up sound waves. You will often see a person who is a little deaf placing the hand behind the ear to assist it in gathering up sound waves. Ear trumpets are also used for this purpose. The drum is a membrane (the *tympanic membrane*) stretched across the lower end of the canal. It vibrates like the head of a drum when the sound waves strike upon it. Glands along the canal secrete the **wax** which guards the entrance to the drum.

The parts of the ear

(2) The ***middle ear***, or ***drum cavity***, is connected with the throat or pharynx by a small canal called the ***eustachian tube***. The object of this tube is to allow a change of air in the drum cavity so as to keep it at about the same density or pressure as the air outside. Otherwise the tympanic membrane might be bulged inward or outward by the unequal pressure on its two sides.

The air in the ear may be changed in the following manner: Take a full breath and then hold the nose tightly closed by grasping it between the thumb and finger. Keep the mouth shut and try to force the air out. As the air cannot pass out through the nose or mouth, it is forced up through the eustachian tube to the middle ear. It cannot pass through the ear, unless the drum membrane has been torn. When an opening has been made in the membrane, a whistling sound may be heard when the ears are inflated in this way. This inflation of the ears should not be repeated very frequently, but it may sometimes give relief and restore the hearing when the ears are "stuffed up" by a cold.

Passing across the middle ear, from its outer to its inner side, is a chain of three very small bones (the *hammer*, *anvil*, and *stirrup*). These bones are bound together and attached to the walls of the drum cavity by ligaments. They are arranged in

such a way that when the drum membrane is made to vibrate by sound waves, the motion is communicated by them to the *cochlea*. The cochlea is given this name because it is shaped like a snail shell. It contains a great number of nerve fibers of different lengths and is thought to be the part of the ear which distinguishes musical notes.

(3) The cochlea is situated at the entrance to the inner ear, which consists of small bony spaces and tubes called the *bony labyrinth*, within which is a *membranous labyrinth*. The membranous labyrinth is lined with very sensitive cells, between which are the endings of the nerve fibers that connect the ear with the brain.

We can now get some idea of what takes place every time we hear a sound. The vibrations or sound waves are concentrated by the outer ear. They strike upon the drum, and are communicated from it to the chain of small bones which transmit it to the inner ear, where it makes an impression upon the sensitive nerve endings. This impression is transmitted through the *auditory nerve* to the brain, producing the sensation of sound.

The ears have no lids or natural covering by means of which they can shut out sound as the eyelids shut out light. The nerves of the ear remain active during sleep, reporting all noises to the brain. The sounds to which one is accustomed do not prevent sleep, although impressions brought to the brain through the ear are often curiously woven into dreams. Unusual sounds generally cause awakening. Why?

The care of the ears

An examination of hundreds of children in Europe showed that one quarter of them were a little deaf, many of them without knowing anything about it. Children are sometimes thought to be dull and inattentive when the real trouble is that they do not hear well what is said to them.

It is a good thing to have the ears tested to find out if the

hearing is perfect. A simple test which you can make for yourself is to find out how far away you can hear the ticking of a watch. If your hearing is good, you should be able to hear the watch when it is held as much as six feet away from your ear.

ONE SHOULD BE ABLE WITH EACH EAR TO HEAR A WATCH TICK AT A DISTANCE OF SIX FEET. THE EYES SHOULD BE CLOSED WHEN THE TEST IS MADE.

If you hear very much better with one ear than with the other, or if you cannot hear the watch tick at a distance of more than forty inches, your ears should be examined.

Sometimes a cold will cause deafness for a time. Catarrh of

the nasal passages or of the throat may spread to the eustachian tube and cause serious trouble. One who wishes to have good hearing will be careful not to take cold. Diseased tonsils are often a cause of deafness and on this account, as well as for other reasons, should be removed. Both ears should be carefully examined whenever the tonsils are known to be diseased.

Children sometimes shout or blow into each other's ears for fun. This is very dangerous. It may send such a strong air current down the canal as to rupture the drum membrane and cause total deafness. A blow on the ear or on the side of the head may also seriously injure the ear.

The drum may be torn and the hearing injured by using a sharp instrument, such as a pin or a toothpick, to clean out the ear. The wax in the ear is placed there by nature as a protection and ordinarily should be left undisturbed. If the ears are carefully washed and wiped out every day, there will be little danger that the wax will harden and cause trouble.

If anything accidentally gets into the ear, do not work at it. Hold the head over to one side while water is sprayed into the ear from a syringe. If an insect gets into the ear, a little oil will kill it so that it can be removed or will make it come out.

Health Problems

1. See if you can prove that the head of a drum vibrates when it is struck. See also if you can prove that a tuning fork vibrates when it is giving forth sound.

2. Show whether the receiver of the telephone is like the drum of the ear in any respect.

3. Is "eardrum" a fitting term to apply to the membrane in the ear upon which sound waves strike? Why?

4. Try to imagine what goes on in the ear when one is walking along a very noisy city street. Do you think this is good for the ear? Why?

5. Suppose the outer ear should be lost, what would be the effect upon the hearing?

6. If you go from a low plain to the top of a high mountain, which way will the eardrum bulge when you reach the top? Why?

7. When a person, in crossing a mountain, has trouble with his ears, physicians try to open up the eustachian tubes. Why?

8. Why can one usually sleep soundly when the wind is blowing moderately or when his bedroom is near the edge of a lake or river where the water can be heard lapping on the shore?

Review Questions

1. Describe the experiment which was made to show what it is that gives the sensation of sound.

2. What are sound waves?

3. How can one illustrate the traveling of sound waves by throwing a stone into the calm water of a pond?

4. What is the eardrum?

5. Why is it that some sounds are higher than others?

6. What is the smallest number of vibrations a second that the ear can hear? What is the largest number?

7. What makes it possible for us to recognize the voice of a friend?

8. What is the outer ear?

9. Where is the auditory canal?

10. Where is the eustachian tube? How does it assist in hearing?

11. What is likely to happen when the eustachian tube becomes clogged?

12. Describe the three small bones in the middle ear.

13. Just what takes place in the ear when we hear a sound?

14. Is there anything in the ear corresponding to the eyelid which covers the eye?

15. Can one shut out noises during sleep?

16. What kind of noises are likely to keep one awake?

17. How can one test his hearing to find out whether it is normal?

18. Why will a cold sometimes cause deafness? It is said that catarrh often causes deafness. How is this possible?

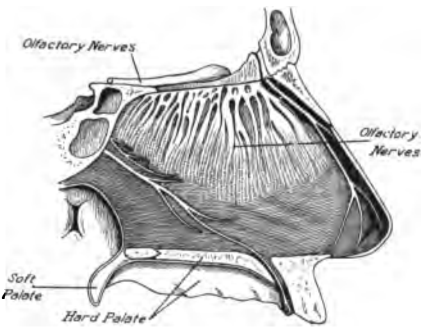
19. Should children shout into the ears of one another? Why?

20. What may be the effect upon the eardrum of a blow on the ear? What is the danger of using a toothpick or a pin in the ear?

CHAPTER XVII

Gateways of the Mind — Smell, Touch, and Taste

Perhaps you know that the sense of smell does not play so important a part in the life of human beings as it does in the life of some of the lower animals. Do you think it may be that it has been largely lost in man through neglect of use? In a dog this sense is so acute that it seems often to be of more service than the sense of sight.



This diagram of the nasal cavity shows the olfactory nerves. These are the only nerves in the body exposed to the outside world.

The *olfactory nerves*, or nerves of smell, end in the mucous membrane of the upper part of the nasal cavity. Here are situated delicate cells very sensitive to odors. These are the only nerve cells in the body exposed to the outside world. From the olfactory cells in the nose, nerve fibers pass to the brain.

The sense of smell is excited only by very small particles of certain substances brought to these sensitive cells by moving air. This is why we "sniff" the air when we wish to smell anything.

When substances having an odor are held in the mouth, the particles that give the sensation of odor are carried through the nose by the outgoing breath. Those sensations of smell we often confuse with taste. We frequently think we taste some-

thing which in reality we only smell. Try this experiment, hold the nose so that the breath cannot escape through it, while a piece of onion is held on the tongue. You will then notice that you cannot taste the flavor of the onion. When the nose is obstructed by a cold the sense of smell is greatly lessened or even lost for a time. At such times the most highly flavored substances seem to have little or no taste.

Confusing smell and taste

Neglected colds, which result in chronic catarrh of the nasal passages, may lead to entire loss of the sense of smell. The mucous membrane may become thickened, so that the odorous particles carried by the air cannot come in contact with the nerves of smell. The use of snuff and cigarettes are also likely to be destructive to this useful sense. Tobacco smoke has a paralyzing effect upon the nerves, besides inflaming the mucous membrane.

Destroying the sense of smell

The brain receives valuable information through the sense of smell, as well as the pleasurable sensations caused by delightful odors. It helps us in determining whether articles are fit for food. Food that is beginning to spoil usually gives forth an unpleasant odor. The sense of smell also warns us of the presence of poisonous gases in the air. It is a signal placed at the entrance of the body, and its warnings should be promptly heeded. When neglected, it soon ceases to give warning of the presence of danger. This is shown by the sensation experienced on entering an unventilated bedroom, or a crowded room, after a walk out of doors. The new arrival is surprised that the persons in the room can endure the unpleasant odor which he at once recognizes. But if he remains in the room for some time, he soon becomes as unconscious of it as the others.

Examine your tongue, and you will find on its surface many little prominences which are called *papillæ*. If you look closely

enough, you will notice some large papillæ that project quite prominently above the others. These large ones are called the *papillæ circumvallatæ*, because there is a little valley or furrow surrounding each one. The purpose of this little trough is to receive the fluids of the mouth in which are dissolved the savory substances of the food. In the trough are the taste buds, each one of which is the expanded end of a bunch of nerves. These taste buds are made up of thousands of delicate nerve filaments which by means of their arrangement are brought into direct contact with the liquids containing the flavors of the food. If these sensitive, jellylike masses were right on the surface of the tongue, they would soon be injured. They are protected by being hidden away down in these little grooves. (See page 27.)

The sense of taste, a sentinel of the body

The flavor of many substances that we think we taste is really due to the odor, as we noticed above. There are only four true taste sensations: sweet, sour, salt, and bitter. It has been shown that each of these is recognized by a special set of nerves. Bitterness is most distinctly recognized at the back of the tongue, and the other flavors at the tip and sides.

Should you expect that condiments, such as mustard and pepper, and all substances which burn the tongue, would injure the nerves of taste and lessen their ability to recognize flavors? Why? Should you expect that alcohol would paralyze the nerves of taste? Why? A teaspoonful of alcohol held in the mouth for a few minutes will so benumb the nerves that ordinary flavors cannot be detected. The habitual use of alcohol permanently injures this valuable sense.

The sense of taste is given to us not merely as a means of pleasure but as a guide to our appetites. It is one of the most important safeguards of the body. The old proverb, "Hunger is the best sauce," is a true one, because when we are

hungry almost any sort of wholesome food can be eaten with relish. When the sense of hunger is satisfied the food no longer tastes so good. A natural taste is a sentinel which promptly indicates to the eater, whenever this is necessary, that enough of any sort of food has been taken to satisfy his present needs.

The sense of touch

Another important avenue to the mind, through which a great amount of valuable information comes to us, is the sense of touch. The nerve endings of this sense are in the skin. Wherever these nerves are most abundant, the sense of touch is most acute, — in the ends of the fingers, the lips, and the tip of the tongue. When we touch anything, the outer skin or epidermis is pressed upon these nerve endings, and an impulse is started to the brain, causing a sensation of feeling.

In the blind the sense of touch becomes very acute, because it must take the place of sight.

The mind is able to discern many of the characteristics of objects through the sense of touch. By its aid we are able to distinguish the forms of objects, and can tell whether they are smooth or rough, hard or soft, rigid or elastic. A little baby, reaching out with its hands to take hold of everything it sees, is making an unconscious effort to inform its mind and develop its judgment by means of the sensation of feeling.

The delicacy of the sense of touch may be greatly increased

by cultivating it. In the blind, in whom it has to take the place of the sense of sight, it is very acute.

The attainments possible through long training of the sense of touch is shown in the case of Helen Keller, who lost both sight and hearing before she was two years old. From that time the only avenue to her mind (with the exception of taste and smell) was the sense of touch. Yet she acquired successfully a college education and has become better informed than most persons having the use of all their senses. It has often been said of her that she "sees more with her fingers than other persons with their eyes."

Besides those that are stimulated by touch, there are nerves in the skin that are stimulated by heat and others that are stimulated by cold. It is a curious fact that warmth and cold are not felt on the same spot of skin. The hot spots and cold spots are arranged in curved lines or chains, starting from the hair roots.

The sense of temperature

The effect that may be produced upon the body by temperature, acting through the nerves that carry to the brain the sensations of heat and cold, has already been studied. We have seen that by the stimulation of these nerves, impulses may be carried to every organ and tissue, increasing the blood circulation and exciting bodily activity.

A daily cold bath furnishes good training of the nerves and the brain, as well as of the skin and its vessels. The impression made by the contact of the cold water with the skin sends a thrill from the surface to the center, stirring every cell and fiber. By the cold bath the whole body is aroused and energized.

The use of pain

Another sensation with which we are all familiar is pain. It is not known whether this sensation has its own special sets of nerves, but it is thought that it is caused by too great stimulation of any of the nerves of feeling. Although

unpleasant and hard to bear, pain is one of the most useful sensations that we experience. It is a danger signal, calling our attention to the fact that something is wrong and needs attention.

Pain is often a means of preserving the body from serious injury. For example, if it were not for the pain a little child might keep its hand in a fire until it was destroyed. Toothache is a warning that a tooth is beginning to decay, a fact that otherwise might not be discovered in time to save the tooth.

People often try to stop or kill pain by drugs or other means, but pay no attention to the trouble of which the pain is giving them notice. This is as foolish as it would be to kill a sentinel because he gave us warning of an approaching danger, and then to go on, making no effort to avert the danger.

The wise thing to do is not to take some kind of "pain killer" but to find out what is causing the pain and to try as far as possible to have it remedied. This can best be done by consulting a reliable physician and acting upon his advice.

Health Problems

1. How does a dog or other animal use the sense of smell? Suppose the animal should lose this sense, could it get along without it? Why?

2. Do you think the horse makes more use of the sense of sight than of the sense of smell? Give reasons for your answer.

3. We say that animals "prick up their ears" when their attention is attracted by any noise. Do they do anything resembling this when their attention is attracted by odors?

4. A lion when he is stealing upon prey, or a hunter when he is tracking an animal, approaches against the wind. Why does he do this?

5. Suggest two or three good tests to show how the sense of smell helps the sense of taste. Does food with a disagreeable smell ever have a good taste? If you think so, give an example.

6. Why has Nature arranged for taste and smell to work together so closely?

7. Why has Nature arranged for some odors to affect us pleasantly and for others to affect us disagreeably?

8. Try a bitter tasting object on the tip of your tongue to see if you can detect the bitterness.

9. Put something sour as far back on the tongue as possible to see if you can taste its sourness. Explain.

10. Why does Nature arrange for an article of food not to taste so good as at first, when enough of it has been eaten?

11. Why has Nature made the sense of touch so acute in the tips of the fingers, in the lips, and on the tip of the tongue?

12. In what parts of the skin is the sense of touch very dull?

13. Why does fresh cold air help to give one a good appetite?

Review Questions

1. How is it possible for odors to make an impression on the brain?

2. What is the meaning of *olfactory?* What are the olfactory cells? The olfactory nerves?

3. Why do people "sniff the air" when they want to smell anything?

4. When one has a cold or catarrh, why does food often lose its taste?

5. What is likely to be the effect of cigarette smoking and snuff taking upon the sense of smell?

6. Can the sense of smell become accustomed to disagreeable odors so that one cannot detect them? Give illustrations.

7. If you examine the surface of the tongue, what do you find there?

8. Where are the taste buds? Of what use are they?

9. Suppose the taste buds were on the surface of the tongue, what might happen to them?

10. What are the true taste sensations?

11. On what part of the tongue is sourness recognized? Where are the other flavors recognized?

12. What is the effect on the sense of taste of condiments such as mustard and pepper?

13. What is the effect of alcohol on the sense of taste?

14. Why is one's natural taste a sentinel?

15. Where are the nerve endings for the sense of touch?

16. Where is the sense of touch most delicate?

17. What can the mind find out about objects through the sense of touch?
18. What is meant by the "sense of temperature"?
19. What effect may be produced on the body by cold?
20. Why will a cold bath stimulate every part of the body?
21. What is pain?
22. Are pain sensations useful to the body? Explain.
23. What is it wise to do when attacked by pain?

CHAPTER XVIII

Two Enemies of the Body — Alcohol and Tobacco

The first thing that any one who wants good health should do is to guard against the enemies of the body. We have already learned about some of these enemies; but we must give special attention in this chapter to two of these, because of the great harm they will do the body unless we can avoid them.

There are certain poisonous substances, very harmful to the body, which are yet capable of giving rise for the moment to pleasurable sensations. They give one a feeling of happiness, of well-being, or comfort. For this reason, they have come to be largely used by human beings, in spite of their poisonous character. Among those chiefly used in this country are alcohol and tobacco.

Alcohol is closely allied to naphtha, benzine, and kerosene, which no one would think of drinking. In a pure state, alcohol destroys instantly all living tissues with which it comes in contact. It is seldom found pure, usually containing from two to fifty per cent of water.

Alcohol kills living things

If a plant be watered with diluted alcohol, its leaves will soon wither and turn yellow; and the plant will die. A tadpole dropped into a vessel containing alcohol will die in a minute. Alcohol, taken even in small doses, has an injurious effect upon the living tissues of the body. A curious accident which happened to a hunter many years ago made it possible to find out the exact effect which alcohol has upon the stomach. A Canadian trapper and hunter, named Alexis St. Martin, was shot in the stomach. The wound was so large that the flesh did not close up and heal the wound in the

usual way. It healed only the edges, leaving a hole two and one half inches around. A fold of lining of the stomach hung down and formed a kind of curtain over the opening. This could be pushed back so that one could look in and see what went on in the man's stomach, just as Professor Pavlov was able to look into the stomachs of his dogs.

Dr. Beaumont, a physician in the United States Army, invited this man with a window in his stomach to come and live with him. He wanted to be able to look in whenever he pleased, and see just how the stomach acted under different conditions. Among other things, he wanted to find out if alcohol was helpful to the stomach in its work or if it hindered it and injured it.

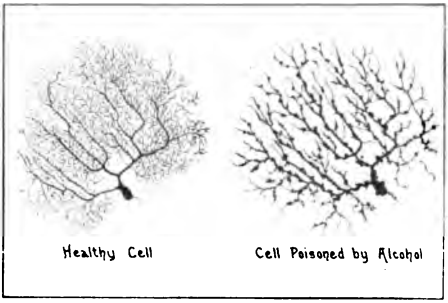
Dr. Beaumont noticed that when Alexis was given good food with no alcohol, the stomach lining was of a pink color, and the gastric juice was thin and colorless. Then he tried giving him a small amount of alcohol every day. He soon noticed that the lining became of a red color, because it was irritated and inflamed by alcohol. After a while, small sores or ulcers formed on it. He removed some of the gastric juice with a tube and found that it contained a thick mucus and sometimes blood from the sore places. He then stopped giving the alcohol and the stomach gradually healed and returned to its natural pink color. By this Dr. Beaumont knew that the continued use of alcohol causes disease of the stomach.

Some of the effects of alcohol upon the human body

Alcohol does more than simply irritate and inflame the stomach. It is able to paralyze the nerves so that they will lose their sensibility. On one occasion, when Alexis St. Martin had been drinking heavily for several days, Dr. Beaumont noticed that his stomach was much inflamed and ulcerated, but Alexis himself knew nothing about this. He felt no pain or discomfort in his stomach but only complained of having a severe headache.

The liver, as well as the stomach, is injured by the use of alcohol. In one who indulges in alcohol for years, it becomes shrunken, hard, and almost useless. The outside becomes covered with little knobs so that it looks like the sole of an English cartman's shoe. The condition has for this reason been given the name, "hob-nailed liver."

Alcohol has the effect of hardening the tissues. The brain in a healthy state is so soft that it would not retain its exact form if it were not supported by the skull. The sharpest knife is required to cut it without tearing it. If a careful examination of a brain is to be made, it is necessary to put it in alcohol for weeks or months in order to harden it. But the brain of a drunkard is already more or less hardened. An anatomist declared that he could tell a drunkard's brain in the dark by the sense of touch alone.



ALCOHOL IS A POISON WHEN TAKEN FREELY. IT AFFECTS NERVE CELLS SO UNFAVORABLY THAT MEMORY AND REASON, — IN FACT, ALL THE MENTAL PROCESSES, — ARE IMPAIRED.

Experiments upon living animals have shown the changes that take place in the nerve cells when alcohol is introduced into the circulation. Some of the cells almost immediately become shriveled, misshapen, and incapable of performing their duty. The delicate branches by which the cells come in contact with each other are drawn back. The contact of the cells is thus interrupted, and this interferes with memory, reason, and judgment. This explains, as we have seen, the mental disturbances which take place in one who drinks freely of alcoholic beverages.

When an animal experimented upon with alcohol recovers from an intoxicating dose, the nerve cells regain their natural appearance. But when the use of alcohol is habitual and long-continued, some of the cells become permanently injured. Then the brain, mind, and character are permanently changed.

Life insurance companies know that one who uses alcohol is not a "good risk." He is not likely to live so long as one who does not. Statistics based on their tables show that the mortality of liquor users is five hundred per cent greater than that of abstainers. It has also been shown that at twenty years of age, a temperate man has an average chance of living for forty-four and one fifth years, while the drinking man has the prospect of only fifteen and one half years.

The effects of alcohol are often seen even more plainly in the children of those who use it than in the users themselves. A French physician, Dr. Legrain, made some investigations to find out what effect alcohol had upon the children of parents who used it freely. This is what he found: "In the first generation from inebriety the mental and physical degenerates were 77 per cent of all; in the second generation, 96 per cent were defectives; in the third generation not one escaped; all were idiots, insane, hysterical, or epileptic."

Alcohol a deceiver

All these things show us that alcohol is a deceiver; it only increases all the miseries that it promises to relieve. It relieves hunger, because it takes away the appetite and the power to digest food; but it does not nourish the body. It soothes pain by paralyzing the nerves, but it does not remove the cause of the pain. If a man is cold, it gives him the sensation of warmth, but he is actually colder than before. It makes the weak man feel strong, but he is actually weaker than before. It causes the nervous system to falsify and to make a man think he is happy, while he is all the time becoming more wretched,

In 1862 the attention of the French Emperor was called to the fact that the number of lunatics, paralytics, and epileptics in the hospitals of France was five times as great in proportion to the population as it had been thirty years before. There was also, it was noticed, about five times as much tobacco being used as thirty years before. It was thought that there might be some connection between these two things, and the Emperor appointed a committee of scientific men to make an investigation.

Tobacco a cause of disease

THE TOBACCO PLANT

In the course of this investigation, the students in the government training schools were divided into two classes — smokers and non-smokers. The physical condition of each class was carefully noted, as well as the amount of work they were able to do. It was found that the non-smokers were much superior, physically, mentally, and morally, to the smokers. A law was at once passed forbidding the students in the government training schools to use tobacco.

Dr. J. W. Seaver, Professor of Physical Education at Yale, has made a careful study of the influence of tobacco upon the bodies and minds of the students. He found that during three and one half years of undergraduate life, the non-smokers increased in height 24 per cent more than the smokers; in girth of chest, 26 per cent more; and in lung capacity 77 per cent more.

A professor in the Kansas State Agricultural College recently examined the condition of 2500 school boys who smoked cigarettes. In one group of twenty-five school boys whose average age of beginning to smoke was thirteen years, he found the fol-

lowing conditions: sore throat, 4; weak eyes, 10; pain in chest, 8; short wind, 21; stomach trouble, 21; pain in heart, 9.

In the high schools in Wisconsin, it was found that nearly all the boys who were dropped because of poor work or who were expelled for one cause or another were smokers. Those who used tobacco were almost always behind those who did not use it.

That many boys and young men are being injured by smoking was shown in the military examinations during the late war. The examining physicians had to refuse a very large number of those who wanted to enlist in the army because they were suffering from "tobacco heart" caused by smoking.

Two rabbits made to inhale tobacco smoke as an experiment died within a month.

Bees, flies, and other insects are quickly killed by directing upon them a stream of tobacco smoke.

Nicotine is an oily liquid which is the essential principle of tobacco. According to Professor Shoemaker, eight drops of nicotine will kill a horse, two drops a dog, and one twentieth of a drop will kill a frog. Numerous experiments have proved that nicotine is a poison to the heart and blood vessels.

These things show us that tobacco is another of the deceiving drugs that promises happiness and brings trouble. It makes slaves of its young victims, while it gradually injures them.

Tea and coffee are not healthful beverages because they contain a nerve poison, caffein. Kola drinks also contain caffein. Tea and coffee produce sleeplessness because caffein irritates the nerves and destroys the sense of fatigue. It is very evident that a drug which will make it impossible for a person to sleep when he really requires rest and sleep must be a powerful poison and very harmful to the nerves. Caffein injures the blood vessels. On this account tea, coffee, and kola beverages

tend to cause high blood pressure. In many persons a single cup of coffee will cause trembling of the hands. A person who wishes to live long and have steady nerves will avoid tea, coffee, and all beverages containing caffein.

Health Problems

1. Put a little alcohol diluted one half with water on the leaf of a plant, and describe what happens to the leaf.

2. Try putting some alcohol diluted one half on the roots of a growing house plant, and describe what happens to the plant.

3. Why is it impossible for a drunken man to reason or to attend his business?

4. Why is it that men when intoxicated often use coarse speech which they would not use were they sober?

5. Why do drunken men often want to engage in a brawl?

6. In some of the universities there are delicate instruments which are used to see how quickly one can act at a given signal and how quickly he can choose between lines of action. It has been found that alcohol always interferes with rapid action and accurate choosing. Explain.

7. Why will a man on an athletic team be instantly dismissed if he is caught indulging in alcoholic drinks?

8. Judges say that most crimes are due to the use of alcohol. Should you expect this? Explain.

9. Sometimes you hear men say that if they stop smoking for a while, and then start again they are made sick by a cigar or pipe. Explain.

10. China is doing everything it can to drive opium out of the country, because, the Chinese say, it has held back their people for centuries. Do you think tobacco may have, to some extent, the same effect upon the people in our country?

Review Questions

1. What poisonous substances may give pleasurable sensations for the moment?

2. What will alcohol in a pure state do to any living tissue with which it comes in contact?

3. Describe the accident which happened to Alexis St. Martin and the study that was made of his stomach.

4. What was found regarding the effects of alcohol on the stomach of St. Martin?

5. How does alcohol affect the nerves?

6. How does alcohol affect the liver?

7. What is meant by "hob-nailed liver"?

8. If a brain is placed in alcohol, what change will take place in it?

9. Why can an expert anatomist tell a drunkard's brain in the dark by the sense of touch alone?

10. What happens to the nerve cells when alcohol is put into the blood?

11. What do life insurance companies say about the use of alcohol? Will they insure a man who does not drink liquor for less than they will insure one who does? Why?

12. Is it right to speak of alcohol as a deceiver? How does it deceive one?

13. What did the French government find about the effects of tobacco upon the nerves of the people of France?

14. Why was a law passed in France forbidding the students of government training schools to use tobacco?

15. What has Doctor Seaver of Yale University found regarding the effects of tobacco?

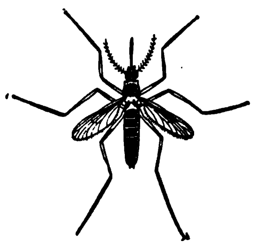
16. Why are coffee, tea, and kola drinks harmful? What are some of the noticeable effects of these drinks?

CHAPTER XIX

Other Enemies of the Body — Disease Germs

In this chapter, we must bring together all we have learned about those deadly enemies of the body, disease germs, and add some new facts. When there is an outbreak of disease in a community, some of the people exposed to the germs take the disease, become very sick, and perhaps die, while others escape entirely. Why do not all the people exposed to the germs become sick?

A healthy human body is able to defend itself quite well against all kinds of germs. Only when they attack in overwhelming numbers, or when the natural defenses of the body have been weakened, are they able to gain a foothold in the body. Yet in the warfare that is constantly going on between mankind and these invisible foes, a large part of the human race is destroyed. What are some of the reasons for this?



Yellow fever germs are carried by a mosquito.

You know already that when we speak of disease germs we refer to those little plants (*bacteria*) and animals (*protozoa*) that are capable of growing in the bodies of human beings and animals and causing disease. Where are these most likely to be found?

You have learned that the germs of tuberculosis may be blown about in the dust of the street and that typhoid fever germs may be carried by water or milk. Scarlet fever and other disease germs

may be found in milk. Diphtheria germs have been found on drinking cups. The germs are conveyed to these places in some way from the bodies of persons sick with these diseases. The only place where the disease germs can multiply is in the bodies of the sick. You can see, therefore, why it is of the utmost importance that all material coming from the bodies of the sick should be disinfected or destroyed so that the germs may not be scattered about to infect other people. If this were always done as it should be, do you not think that many diseases might be completely stamped out in a short time?

The germs of different diseases have different methods of getting into the body. To know the ways in which they are most likely to enter may help us to guard against them. Some may be introduced by the bites of insects. A certain kind of mosquito spreads the germs of malaria. Another kind introduces into the body with its bite the germs of yellow fever. Fleas, carried by rats, spread the germs of plague. Sometimes pus-forming germs work their way into the hair follicles and sweat glands of the skin or they get in through scratches or wounds. The germs of colds, tuberculosis, pneumonia, influenza, and other diseases come in through the air passages. Typhoid fever and cholera germs get into the body through impure water and sometimes with the food, which may be infected by flies or through being handled by persons contaminated with typhoid or cholera germs.

How germs enter the body

TYPHOID FEVER GERMS ARE SOMETIMES CARRIED ABOUT AND NOURISHED IN OTHERWISE CLEAN, GOOD MILK.

When the disease germs once get a foothold in the body, the mischief they are able to work is due to two things: (1) the

great rapidity with which they multiply; and (2) their power to produce deadly poisons.

You may recall how the cells of the body multiply, — by each cell's dividing into two. Most disease germs multiply in the same way, and, as you already know, at a very rapid rate. The germs of cholera, for instance, may become full grown and divide into two in twenty minutes. In this way they can extend their ravages in the body with great swiftness.

The weapons used by our germ enemies in their attacks upon the body are the deadly poisons which they produce. It is these *toxins*, as they are called, which are very violent poisons, that really cause the disease by poisoning the cells of the body. Almost all fevers are caused by these germ-formed poisons. Some germs produce stupefying poisons; others, irritant poisons; still others, paralyzing poisons. Each class of germ develops its own brand of poison.

These are diphtheria germs. They multiply very rapidly, and so are likely to overcome their victim; but, if taken in time, diphtheria can be cured.

Even when a person is in good health, the healing or restoring process is constantly going on in his body in order to keep him healthy. When one has worked until he is exhausted, he must recover from his fatigue before he can undertake fresh work. The digestion of a meal, for example, leaves the stomach in a congested state, from which it must recover before it is ready to digest another meal. The body is being continually worn by its work and so it needs constant restoring. This work is done by what we call the natural forces of the body; that is, by the power of the body to heal itself.

How the body heals itself

The healthy body is able to defend itself against germs in a variety of ways. The skin is an outer defense which in a healthy state cannot be penetrated by germs. The mucus of the mouth and nose has some power to prevent the growth of germs and even to destroy them. The cells which cover the lung surface are constantly engaged in capturing and destroying germs. The gastric juice is a powerful germicide, or germ killer, capable of destroying the germs of cholera, typhoid fever, and any other germs that are likely to get into it. The white cells of the blood are the special defenders of the body against germs that enter the tissues, and the plasma, or *serum*, also has power to destroy germs.

When, through the weakening of the natural defenses, the germs are able to gain a foothold in the body, great injury may be done. The germ poisons irritate or paralyze the tissues, and cause inflammation, congestion, pain, and other disturbances. The body must then make a special effort to do the healing, and it has to rally all its forces to meet and conquer the invading army. This it does in two ways: (1) by increasing the number of white cells; (2) by the formation of special germ-killing substances in the blood called *antitoxins* to act against the toxins made by the disease germs.

You remember how the white cells in the blood seem to be attracted to the germs that get into the body and how they inclose or swallow them. Then ensues a struggle in which the germ tries to kill the corpuscle, and the corpuscle tries to digest and kill the germ. The life of the person in whom this fight is going on depends upon which wins the victory, the corpuscles or the germs. All that the doctor or nurse can do is to help the body to summon all its natural forces, and to try as far as possible to assist the little soldiers in their fight.

As each class of germs has its own particular poison, so the

body produces a special germ-killing substance suited to the particular kind of germ by which it is being attacked. You know there are diseases, such as smallpox and scarlet fever, which a person usually has but once. A person who has had smallpox may afterward go among people suffering with this disease without any danger of infection. He has become immune to that disease; that is, that particular kind of disease germ can no longer grow and multiply in his body. The reason for this seems to be that the special substance required to kill that kind of germ remains in his blood through life and promptly kills any such germs that may enter. Some diseases we may have again and again, because the germ-killing substance for those particular germs quickly passes out of the blood.

Guarding against disease

Since we are in constant danger of attack from disease germs, it is necessary to be constantly on guard against them. What are some of the ways in which we may be protected from attacks of this sort? In the first place, by means of public hygiene or sanitation we may protect ourselves. The health and sanitary officers in a community may be looked upon as a sort of advance guard or scouting party. They go out, armed with microscope and test tube, to spy out the enemy, — to find out where the disease germs may be lurking and from what point they are likely to make their attack. If possible, they destroy them before they

HERE IS A DROP OF WATER GREATLY MAGNIFIED SHOWING ORGANISMS, STILL MORE HIGHLY MAGNIFIED, THAT MIGHT CAUSE DISEASE IF ONE SHOULD DRINK THE WATER. SUCH WATER IS NOT SAFE TO DRINK WITHOUT LONG BOILING.

have a chance to do any mischief. When this is not possible, they warn people so that they may be on their guard. They compel people to put a large placard on a house when any one inside is sick from an infectious disease. They examine the drinking water and see that there is a pure supply or that people are warned when their supply contains disease germs or parasites. They inspect the food supplies in the markets and stores and order any that are unfit for food to be promptly destroyed. When there is an outbreak of disease in a community, they search out the cause and see that it is corrected.

In the World War special attention was given to sanitation. Officers were always sent out in advance with the army scouts. They tested all the wells and labeled them so that the soldiers would know if the water was fit for drinking. They went with the foraging parties and sampled all the food, fruit, and vegetables sold along the line of march. They examined the sanitary conditions of every town before the army arrived. If there was any danger from infection, the place was quarantined and guarded. In the camps, they taught the soldiers how to protect themselves.

As the result of this careful attention to sanitary conditions the percentage of soldiers that suffered or died from camp diseases was smaller than ever before in a great war. Typhoid fever was almost unknown among American soldiers, whereas in the Spanish-American War, the death rate from preventable disease was 70 per cent, — only 268 men were killed by bullets, while 3862 died in the hospitals. This will give you some idea of how much may be done by public hygiene to guard people from disease.

As we have public hygiene, so we must have domestic hygiene. You will recall that house dust is very dangerous. It contains germs brought in from the street on the feet, or that have floated

in the air, particularly those of pneumonia and tuberculosis, two of the most dangerous of communicable diseases. Sweeping and dusting are sometimes done in a way that only stirs up germs, and keeps them floating about, instead of getting rid of them. The vacuum cleaner, which sucks up all the dust and scatters none of it, is by far the best method of removing dust from curtains and carpets. The dustless duster or a damp cloth will remove the dust which the ordinary dry duster only stirs up.

Domestic hygiene

The kitchen, pantry, sinks, closets, and cellars need frequent cleaning. Fermenting and decaying materials are always a source of germs, and they should not be allowed to accumulate. Cesspools should be situated far from the house and should be water-tight so that the soil about the house cannot become polluted with drainage. Stables and animal pens should be at a distance from the house and should be kept clean.

Sunlight is Nature's great disinfectant. It destroys germs brought in contact with it. So we should admit the sunlight to every room in the house, closets included, if possible. Let sunlight do its disinfecting work in every nook and corner of the home. Fire is the best of all disinfectants. Germ-producing matter should be burned whenever possible. Ordinary boiling, continued for half an hour, will destroy many kinds of dangerous germs.

Of more importance to the individual than either public or domestic hygiene is personal hygiene — the acquiring of those habits which will keep the germs out of the body and will keep up the natural power of the body to kill them if they should enter.

Personal hygiene

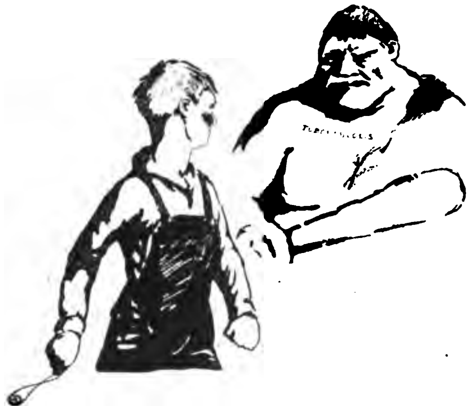
Mention some personal habits which may be a means of introducing germs into the body. Think of the ways in which the hands may gather germs in the course of a day, — from door

knobs, car straps, money, and the hands of other persons. Should there be disease germs upon them, these may get into the mouth with the food or into the eyes if the eyes are rubbed. The simplest and easiest method of disinfecting the hands is by a thorough washing with soap. This is especially necessary before eating. Drinking from a cup used by others is another way by which disease germs may get into the body. At school or when traveling one should always carry a private cup. Avoid putting into the mouth pencils, money, or other articles that have been handled by others.

Among other things it is important to remember that common colds are really infectious; so when one says, "I have caught a cold," he really has in fact been infected through contact with some other person who has a cold, just as he might have contracted smallpox by meeting a person suffering from this disease. We catch colds from people who have colds, not from the weather. It is true that one may contract a cold without having come in contact with another person suffering from an acute cold, for the reason that many persons who are subject to colds are "cold carriers"; that is, they always carry in the nose or throat the particular germs which give rise to colds, and if they happen to lower their resistance a little by loss of sleep, by breathing impure air, by becoming overheated or greatly fatigued, by getting chilled, by becoming constipated, by overeating, especially of meat or rich foods, — in any of these conditions, the germs take advantage of the lowered resistance of the body, rapidly multiply, and produce the poisons which cause the fever and other discomforts which accompany the cold.

It is important to avoid any person suffering from an acute cold. Do not stay near a person who is coughing or sneezing or who is making use of a soiled handkerchief. Such persons are in a highly infectious condition.

POSTURE AND TUBERCULOSIS



Poor posture encourages tuberculosis.
Erect carriage combats it.

Right posture acquired in childhood promotes

- Strong, healthy lungs
- Good Circulation
- Sound health
- Proper growth and development.

Train the child in right posture not by constant nagging, but by suitable exercise, instruction in hygiene and a good example.

One who has a cold should also take care to protect others by avoiding close contact with them, by holding a handkerchief over the mouth when coughing or sneezing, and by taking great care to avoid infecting books, door knobs, or anything else which others may need to handle.

Keeping up body resistance

Even with all the precautions that we have mentioned, it is not possible to keep the body entirely free from disease germs. There are usually present in the body germs capable of producing disease, waiting for a favorable opportunity to attack. These are not to be feared so long as the body is in such a healthy condition that its natural defenses are active. But to let the body get run down or weakened by bad habits is to open the gates to the enemy. This may be done by lack of exercise, bad food, overeating, insufficient sleep, bad ventilation, overwork, or by the use of alcohol. Show why, in each case.

When one country is expecting war with another the standing army is carefully inspected to see that all its soldiers are well equipped and in good fighting trim. Care is also taken that the reserve forces shall be ready if called upon. It is just as important for us, subject as we are to the attacks of germs, to keep our standing army of body defenders in good condition and our reserve forces ready to be drawn upon if necessary.

Health Problems

1. What is the meaning of *the natural defenses of the body?* Is the term "natural defenses" appropriate? Why? Mention some of these natural defenses.

2. How do nurses and doctors generally avoid taking diseases from the sick persons whom they treat?

3. In some cities there are bungalows on the roofs of skyscrapers. The people who build these plan to live in them just as other people live in houses built on the ground. If you were living in Chicago or New York

or any other large city, do you think it would be more healthful to live in one of these bungalows than in the ordinary house? Why?

4. Suppose some one member of the family is always catching colds and coughs, what may be the explanation of this? How should such a person be treated?

5. If you were living in a malarial country, what gateway of germs to the body would you guard particularly? Why?

6. Suppose there was an epidemic of yellow fever in your community, what gateway to the body would you guard particularly? Why? Consider in the same way an epidemic of typhoid fever and of diphtheria.

7. Give an instance of the power of the body to heal itself from some severe injury or illness.

8. You often hear a person say: "I was all run down, and I caught a cold." Just what does he mean by this? Do people catch coughs and colds more frequently when they are "run down" than at other times? Why?

9. Speak of habits you observe in people which are likely to weaken their "natural defenses." Are such persons often ill? Why?

10. Show how the sanitary officers in a community are much like the scouts and pickets in an army. Suppose the scouts and pickets should not do their duty, what might happen to the army? Might it be the same way in a community if sanitary officers were neglectful of their duty?

Review Questions

1. When are germs likely to get a foothold in the body?

2. What are the names used for disease germs?

3. How may the germs of tuberculosis be spread? The germs of typhoid? Of diphtheria?

4. Where are the breeding grounds for germs that cause sickness?

5. How do insects spread disease?

6. How do the germs of colds, influenza, and other diseases get into the body?

7. In what ways do germs harm the body?

8. How do disease germs multiply? How rapidly do the germs of cholera multiply?

9. What is the meaning of *toxins*?

10. How does the body defend itself against its germ enemies?

11. What has Nature provided in the body to kill disease germs? How do the poisons made by the germs work upon the body?

12. What are the chief defenders of the body against disease germs?

13. What do the corpuscles and antitoxins do to help the body in its fight against germs?

14. What does it mean to become immune to a disease? Why does a person have smallpox only once in a lifetime?

15. What are the means of guarding against germ enemies?

16. What precautions were taken to protect our soldiers against germ enemies in the late war?

17. What are some of the ways in domestic hygiene for guarding against disease germs?

18. Mention several good ways to kill germs.

19. What is meant by *personal hygiene*?

20. Mention some habits of life which will enable one to fight disease germs successfully.

21. What does it mean to "open the gates to the body's enemies"?

CHAPTER XX

"CATCHING" DISEASES

No person would purposely plan to make a friend sick. Yet it often occurs that unintentionally one who is ill, by merely going among other persons, causes others to become ill too. This is because the disease he has is *communicable*, or can be passed from one person to another. In other words, it is a "catching" or *contagious* disease. Smallpox, measles, scarlet fever, diphtheria, chicken pox, mumps, and whooping cough are all *communicable* or *contagious* diseases. A child who has any one of these is a danger to other children until he is entirely well, even though he himself may not feel sick. Very severe cases often result from coming in contact with one of these diseases in a mild form.

The danger of contagious diseases

Those who guard the health of the people have made it a law that persons having a communicable disease shall, as soon as this is known, live quite apart from other people. A person who is compelled to live thus apart from others is said to be in *quarantine*. This precaution is necessary in order to prevent others from taking the same disease and is a most important sanitary regulation. With many children, quarantine is the hardest part of the illness, since they must stay at home, and none of their playmates may come to see them. But when one thinks of the risk to others, it seems quite right that a strict quarantine should be enforced in all cases of infectious diseases.

Quarantine

My young friend Georgia, at school one day, complained of having a sore throat. Her teacher at once sent her home, although the girl said she did not really feel sick, and begged

to be allowed to remain. The teacher did not send her away because of her misfortune in having a sore throat, but as a precaution for the rest of the pupils. Did the teacher do the right thing in sending Georgia home?

The teacher knew that sore throat is often a danger signal, and such it proved to be in Georgia's case. Soon after reaching home, she began to feel hot and feverish; and her mother called a physician. When the physician discovered that her throat was sore, he took a small wooden stick from his case. Around one end of this he wound some *sterile* cotton, that is, cotton free from all germs, and made a *swab*. With the swab he wiped the little girl's throat. Afterward he put the substance wiped off on the kind of soil upon which germs like best to grow, — that is, upon a "culture" plate. If Georgia had diphtheria, as the doctor feared, this "culture" would, he knew, show it in a few hours. Diphtheria is always caused by germs. These germs grow on the mucous membrane of the mouth and throat. They are so tiny they cannot be seen with the eye alone. But if some of them are wiped off, and planted on "culture" soil, a microscope will reveal them as they grow. If the throat from which the culture is taken has no diphtheria germs, this, too, will be shown.

How a culture is taken

GEORGIA COMPLAINED ONE DAY IN SCHOOL OF A HEADACHE AND SORE THROAT AND THE TEACHER SENT HER HOME IMMEDIATELY. WHY?

The doctor told Georgia's mother that until he could make a report on the case, it would be safer to put Georgia in a room as remote as possible from those occupied by other people, and to take out of it all but necessary furniture. When Georgia's father built their cottage, he made one room in the upper story that opened upon a covered porch. It was also connected with a small bathroom. There were three nice windows, too, so that there could be plenty of sunshine and fresh air. The room was at the end of a hall, and the family called it their "hospital corner," because in times of illness it made a very satisfactory sick room.

Georgia was put in this room for the night, after her mother had taken out all the extra things. In the morning, the culture taken from her throat showed that Georgia had diphtheria. The doctor said she must not go from the "hospital corner" to any other part of the house, and that no one but the nurse and himself could be allowed in the room with her. To prevent the risk of any other child's entering the room unawares, the nurse kept the door locked.

Diphtheria is a very "catching" disease. Now that it was certain diphtheria germs were making Georgia ill, the doctor said that she and every one in the house should have a dose of antitoxin (*anti* means opposed to, and *toxin*, poison), a remedy that works against the poison which diphtheria germs always make in the body. Have you heard this term before?

Antitoxins and their use

It is only within recent years that it has been possible to secure this remedy. Before its use, only about one half of those who had the disease in severe form got well. But now thousands of lives are saved by the employment of this antitoxin. The more promptly it is given, the better the results. Where it is used within the first twenty-four hours of illness, there is a loss of

only one life in a thousand cases. Do you not think that everyone should make use of this antitoxin when he is is in any danger from diphtheria?

It happens quite often that a person having diphtheria germs, although not at all sick himself, gives the disease to others. Such a person is called a *carrier*, and the health of every one with whom he comes in contact is in danger so long as he has the germs. His own body makes enough antitoxin to defend itself, but that does not mean safety for other people. In some cities, when a case of diphtheria occurs in a school, cultures are taken from the throats of all persons who are in the same classroom with the patient in order to find who the carrier may be. Carriers need to be quarantined and to have the germs in their throats destroyed, just as in the case of a person who is actually sick with the disease.

Precautions observed in quarantine

In the case of Georgia, the health officers had been notified of her illness, and a red placard was put on the door, warning all who came that way not to enter. Why? A notice was placed where the milkman could see it telling him not to leave bottles but to pour the milk into a dish placed especially for him. Why? A poster placed indoors gave directions to the family as to how they must care for themselves and for the diphtheria patient.

Some of the things it said were:

"Diphtheria is always dangerous and easily given to others. It is catching from the mildest form. Those not sick enough to be in bed give the disease to others oftener than the very sick.

"Diphtheria patients must not leave the house until the Department of Health removes the warning card. Neither may people living in the house go in and out. Inmates of the house must stay indoors.

"Visitors are not allowed.

"Groceries and milk must be left at the door.

"School children and others must stay at home. No one living in the

house is allowed to go to church, Sunday school, or to other public places.

"Do not let the patient spit on the floor.

"Spit and nose discharges will give the disease to others, and should be caught on cloths, and burned immediately.

"Do not kiss the patient.

"After touching the patient or anything he handles, *always wash your hands.*

"Everything, — letters, laundry, bedding, books, magazines, papers, and clothing must be disinfected before they are taken out of the house.

"Everything used in the sick room, such as knives, forks, spoons, dishes, books, playthings, handkerchiefs, towels, sheets, pillow slips, clothing, flowers, and remnants of food must be disinfected before being taken from the room."

EVERYTHING A PATIENT SUFFERING FROM AN INFECTIOUS DISEASE USES OR TOUCHES SHOULD BE DISINFECTED, BY BOILING IF POSSIBLE, BEFORE ANYONE ELSE IS ALLOWED TO USE OR TOUCH IT.

To disinfect an article, you will remember, means to do something to the article that will kill all the germs on it. Any article which will not be harmed by boiling may be disinfected in that way. So on a gas plate in the bathroom, Georgia's nurse kept a tin boiler full of water just at the boiling point. All the dishes and everything which Georgia used or touched were, as soon as she was through with them, put into this water, and boiled for twenty minutes. When boiling is not convenient, a metal tub may be

filled with a solution which the doctor will order, and all articles may be soaked in it for sufficient time to make them sterile.

One thing is to be especially remembered whenever a person has a communicable disease: *Nothing must ever be allowed to leave the sick room until the germs on it have been killed by thorough disinfection.*

Georgia's father constructed a very good kind of dumb waiter by means of which meals might be sent up to the sick room. First, he attached a small chain to a large tin bread box. Then by fastening a pulley to the porch railing and adjusting the chain on it, the box could be raised and lowered with ease. The nurse opened the box on the porch outside the door and emptied all foods into the special dishes kept there for Georgia's use and her own. Then she told the one below to lower the box. The nurse was always careful to disinfect her hands before touching the box or its contents, so that not a germ might find its way to the rooms below.

How the disease germs were carried in Georgia's case

The doctor was quite at a loss to know where Georgia could have got diphtheria germs, as no "carriers" had been found. There was not a case in that town, and there had been none for a long time. Neither had Georgia been away on any visits.

"Isn't it odd that my Cousin Ellen should be having the same disease that I am?" said Georgia one morning during the doctor's visit.

"Where does your cousin live?" inquired the doctor.

"'Way up in Canada," replied the little girl.

"Then how do you know she has been sick?"

"Oh, we write letters to each other. She wrote me that she was having to stay out of school because she had been ill with diphtheria. It is queer that the same thing has happened to both of us."

"How long is it since you got that letter?"

"Oh, about two weeks," replied Georgia.

"Well," said the doctor, "it does not seem at all queer to me. It is plain enough now that the germs which are causing you so much unpleasantness came to you sealed up in your cousin's letter. The strange thing is that her people should permit her to send letters while she was ill with a 'catching' disease."

"I guess, perhaps, they didn't know about it," said Georgia, "for Cousin Ellen wrote us that they would not let her go out at all, so she was going to drop her letter out of the window and ask the neighbor girl to post it."

"It would not surprise me if the neighbor girl, too, took diphtheria from that letter," said the doctor. "Diphtheria germs pass from the sick to the well so easily that everything touched by the patient is dangerous until the germs on it are killed; and these germs live a long time.

Animals and playthings may carry germs

"A little boy I knew died from diphtheria. His mother, out of fondness for him, kept his picture blocks and books and toys in a trunk which she stowed away in the attic. Years afterward, some other little children playing in the attic found these playthings, and from them got the germs that made both of them very ill with diphtheria. These facts and many similar ones have made it plain that the greatest care must be taken with regard to all the things that come into contact with those who are ill with diphtheria. The same is true in respect to other 'catching' diseases. So you see it is better always to do exactly what the health boards and those who make a study of these diseases tell us, even though it is not very pleasant at the time."

"May I have my dolly to play with, while I am in quarantine?" asked Georgia.

"You may have anything you want provided you are willing

that it should be burned when you get well," replied the doctor.

"Oh, when shall I be well, then?" she continued.

"When the cultures from your throat show that you no longer have diphtheria germs," was the doctor's answer. "No one can tell just how long that may be, but you can help things along by cheerfully taking your treatments and doing as your nurse tells you."

"And does everything I play with have to be burned?" she asked again.

"Anything that can be boiled without harm can be saved," said the doctor. "There are other ways in which some things can be made safe, but in general it will be wiser to bring nothing up here that you will afterward need or care especially for. Your nurse knows so many nice things to do, you will not miss your dolly, I am sure."

Just then the barking of a dog below called Georgia's attention to her pet, and she asked, "Why doesn't somebody open the door for Gyp?"

"Gyp is in quarantine, too," said the doctor. "He lives in the carriage house now. It would be unsafe to allow him in the house while there are diphtheria germs about. Animals as well as human beings take the disease. Even if Gyp did not catch it himself, he might be the means of giving it to some person, for the germs might get in his hair, and he would scatter them wherever he went. He is made quite comfortable and has plenty to eat, but he doesn't like to be shut out any better than you like to be shut in."

Every day a cot was placed in a quiet corner of the porch. On it Georgia was allowed to lie out of doors where she could watch all that was going on around her and breathe the fresh air.

When she was able to sit up, a large shallow pan of sand placed

on a bedside table afforded her many pleasant hours of play. Out of it she made a farm with valleys and hills, rivers, and lakes. For trees she planted green twigs. A cardboard house and barns, fences of toothpicks, and paper men, women, children, and animals made it seem quite real.

At other times the sand pan was an athletic field where paper boys played ball, or it was a park with flower beds and winding

GEORGIA WILL RECOVER RAPIDLY, SINCE SHE SPENDS MOST OF EVERY DAY OUT IN THE FRESH AIR AND SUNSHINE; AND SHE IS KEPT PLEASANTLY OCCUPIED.

paths, with cages of wild animals. Again it became a model town with broad streets, on which paper automobiles and trolley cars were seen. So many and varied were the things that could be made with that sand pan that Georgia quite forgot she was in quarantine; and she was really a little bit sorry when one morning the doctor said to her, "You have a clean throat, and to-

day, when your nurse has given you a cleansing bath all over, including your hair, you may put on clean clothing and go down stairs."

"May I go to school to-morrow?" she asked.

"Not to-morrow, but in a few days," was the answer. "Culture tests must be made again. The house, too, must first be cleansed of germs so that you will carry none to school."

Years ago people understood little about germs, and their part in the cause of diseases. They knew that certain diseases were "catching," and that these rarely attacked the same individual twice. It was a common belief that everybody must have measles, scarlet fever, whooping cough, chicken pox, and mumps, and that the earlier in life each person took his turn the better it would be for him. Little care was taken to avoid diseases, and sometimes children were sent to visit the sick in order to catch the disease. I suppose you do not need to be told that very many lives were lost through such ignorance.

Health Problems

1. Are pupils ever kept out of your school on account of illness? Who forbids them to come to school?

2. Have you known pupils who have come to school with contagious diseases and have given them to other pupils? Was this fair to the well pupils?

3. Have you been *vaccinated?* What good does vaccination do?

4. Have you known any person who has been given antitoxin? If so, what was the reason that it was given to him? Did it help him?

5. Find out how antitoxin is prepared. Your family physician should be able to tell you.

6. If two people are exposed to diphtheria in the same way, one may catch it and the other may not. Explain.

7. Is there a medical inspector or visiting nurse who visits your school? If so, state just what he or she does. If there is no such inspector, do you think one ought to be appointed? Why?

8. Have you ever heard of a person's being *immune* to certain diseases, such as whooping cough? What does this mean? How is it possible?

Review Questions

1. Mention some common communicable diseases.
2. Would a person who has one of these diseases, but who is not very sick, be a danger to other people, if he should play or study with them? Why?
3. What does it mean to be "in quarantine"? Who in a community has authority to quarantine people?
4. What disease may one be getting when his throat begins to feel sore?
5. How does a physician make a test for diphtheria?
6. When is a thing sterile? How can one make a spoon, for instance, sterile?
7. What is the meaning of a *culture?* How does a physician make a culture of diphtheria?
8. What does antitoxin do in the body?
9. Has antitoxin saved the lives of many people?
10. May a person carry the germs of diphtheria, even if he is not sick himself?
11. Why did the health authorities put a placard on the door of Georgia's house, warning people not to enter?
12. Why did they forbid all the people in the house from going out on the street?
13. What did they put on the poster which they placed indoors? Why is it necessary to give these directions to a family?
14. How does a nurse disinfect the articles used by a sick person? Why was it necessary to be so careful about this?
15. How do people get diphtheria germs?
16. Why are people often careless about sending out letters and other things from those who are sick with contagious diseases?
17. At one time did people think children ought to have all the "catching" diseases? Why?

CHAPTER XXI

Health Crusaders

Almost a thousand years ago a great many men, women, and children of Europe undertook long and perilous journeys to the Holy Land, the birthplace of Christ. They went there with the hope of rescuing Jerusalem from the Turks, who held it and who were hostile to the Christian religion. These travelers suffered hunger and pain without complaint in order that they might help to spread the religion of hope, good will, and charity throughout the world. Their standard — which served the same purpose as a flag — was the cross, and the Latin word for cross is *Crux*, so that all who participated in this undertaking were called "Crusaders"; that is, persons who were loyal and devoted to the cause of which the cross was the standard or emblem. The Crusaders not only wished to reëstablish the Christian religion in the Holy Land, its birthplace, but they sought also to teach the people along the route to the Holy Land the rules of life which their religion upheld. The Crusaders were bent upon doing good to mankind, even at the cost of great suffering and sacrifice to themselves.

The Crusaders of olden times

We of to-day do not need to engage in such crusades as those of long ago; but there is a need to undertake crusades of other kinds. Most important of all, perhaps, is the Health Crusade. We need to fight disease. We need to be devoted to the cause of building our bodies so that they will be sound and strong, and free from defects of every sort. We need to undertake such a program of

The Health Crusade

In days of old, Crusaders bold
Rode forth to fight the foe,
And we to-day, as brave as they,
Forth to the battle go.
Let's fight for health and happiness,
And on each trusty blade,
We'll write the glorious motto, HEALTH!
Hurrah for our Crusade!

Courtesy National Child Welfare Assn., Inc.

daily life that we shall feel well at all times and prepared for any tasks in which we may need to engage. We need to live so that we shall not have to lose time in sickness which we wish to spend in work or in play. We need also to join with our fellows in deterring people who do anything that is dangerous to the health of the public. We need to make everyone understand that he has no right to do anything whatsoever that will cause pain or disease to any one else.

A Health Crusader has everything to gain and nothing to lose

There is a very great difference between the Health Crusade and the Crusades that were undertaken by people in early times. I told you that the Crusaders of olden days often suffered greatly from hunger, fatigue, disease, and hardship that they might accomplish their purpose; but the Health Crusader, instead of suffering any sacrifice or pain or hardship from what he undertakes, lessens pain, disease, and hardship. His purpose is to improve his own health and that of others; and everything he does which helps him to attain his purpose will prevent him from becoming sick, will save him from pains, will make him able to do what he wishes to do more successfully than he otherwise would be able to do it. The Health Crusader increases his strength, his welfare, his happiness, just in the measure that he is a good, loyal, and efficient Crusader. To the extent that he overcomes laziness, carelessness, indifference, ignorance, and appetite, he will be a successful Crusader, and a stronger, more agreeable, and happier person; so that one has nothing to lose and everything to gain by engaging in a Health Crusade.

Some years ago a society was formed for the purpose of combating tuberculosis or consumption. Every one who becomes a member of the society pledges himself to do what is necessary in order to prevent the spread of tuberculosis, and to protect himself against it. There had been so many deaths from this

dread disease that there was danger that our people would be destroyed unless they could stamp it out. Fortunately, every one who lives so as to protect himself against tuberculosis loses nothing in any way, but instead gains a great deal. Protecting one's self against consumption or tuberculosis means that one lives in such a way that he is strong and ready for anything any one of his age ought to be able to do. This society which was fighting tuberculosis started, in 1917, a children's society, the Modern Health Crusaders.

You must not think of the Modern Health Crusaders as sacri-

Courtesy National Tuberculosis Assn.

EVERY MODERN HEALTH CRUSADER PLEDGES HIMSELF TO OBEY THE CRUSADERS' HEALTH RULES.

ficing and suffering as the early Crusaders did. You must rather think of the Modern Health Crusaders as simply taking advantage of what is known regarding ways and means of getting the most out of life. Every Modern Health Crusader pledges himself to do nothing that may hurt the health of any other person, to help keep home and town clean, and to obey the Crusaders' Health Rules; that is, to do certain "health chores" every day. Here are indicated the chores for one day.[1] (Each Crusader has these printed on a chart which he carefully checks from day to day.)

"Health chores"

[1] Further details may be obtained from the National Tuberculosis Association, 370 Seventh Avenue, New York City.

I washed my hands before each meal today.

I washed my face, ears and neck, and I cleaned my fingernails.

I kept fingers, pencils and everything likely to be unclean or injurious out of my mouth and nose.

I brushed my teeth thoroughly after breakfast and after the evening meal.

I took ten or more slow, deep breaths of fresh air. I protected others if I spit, coughed or sneezed.

I tried to eat slowly, and only wholesome food, including milk, vegetables and fruit. I went to toilet at regular time.

I tried hard to keep neat; to be cheerful, straightforward and clean-minded; and to be helpful to others.

I played outdoors or with windows open more than thirty minutes. I tried hard to sit and stand straight.

I was in bed ten hours or more last night, and kept my windows open.

I took a full bath on each day of the week that is checked on my chore record.

I drank four glasses of water, drinking some before each meal, and drank no tea, coffee nor any injurious drinks.

HERE ARE PICTURES OF MODERN HEALTH CRUSADERS.

1. I washed my hands before each meal to-day.
2. I washed my face, ears, and neck, and I cleaned my finger nails.
3. I kept fingers, pencils, and everything likely to be unclean or injurious out of my mouth and nose.
4. I brushed my teeth thoroughly after breakfast and after the evening meal.
5. I took ten or more slow, deep breaths of fresh air. I protected others if I spit, coughed, or sneezed.
6. I played outdoors or with windows open more than thirty minutes. I tried hard to sit and stand straight.
7. I was in bed ten hours or more last night, and kept my windows open.
8. I drank four glasses of water, drinking some before each meal, and drank no tea, coffee, nor any injurious drinks.
9. I tried to eat slowly, and only wholesome food including milk, vegetables, fruit. I went to toilet at regular time.
10. I tried hard to keep neat; to be cheerful, straightforward, and clean-minded; and to be helpful to others.
11. I took a full bath on each day of the week that is checked (x).

Honors for Health Crusaders

In the days of the old Crusades a youth was given honors gradually, according as he showed that he had courage, endurance, loyalty, devotion, and intelligence. When he first began to prepare to be a Knight he was known as a *Page*. After a certain period when he had been well tested, if he made a good record in regard to each of the qualities required, he won the title of *Squire*. If he continued to show improvement in respect to all the required qualities so that he became proficient in each one, he was given a higher honor; that is, he was made a *Knight* or, better still, a *Knight Banneret*. With the modern Health Crusaders, there are

Courtesy National Tuberculosis Assn.

THIS IS A REPRODUCTION OF THE PIN WORN BY A KNIGHT.

the same ranks. In order to become a Squire one is required to do at least fifty-four health chores in each of five weeks. During the first five weeks he is a Page. He must do at least fifty-four chores for ten weeks in order to become a Knight, and he must do them for fifteen weeks to become a Knight Banneret. A higher title even than Knight Banneret may be won. This will be mentioned at another point in the chapter. Any one who does these chores for fifteen weeks will so have formed the habit that he will probably continue to do them. He will have discovered then that doing health chores means simply living in ways that will yield the greatest amount of health, strength, and happiness; and when one finds this out he will not be willing to drift back into bad habits which result in aches, pains, disease, and inefficiency. In the olden days only boys became knights; but both boys and girls take part in the Modern Health Crusade.

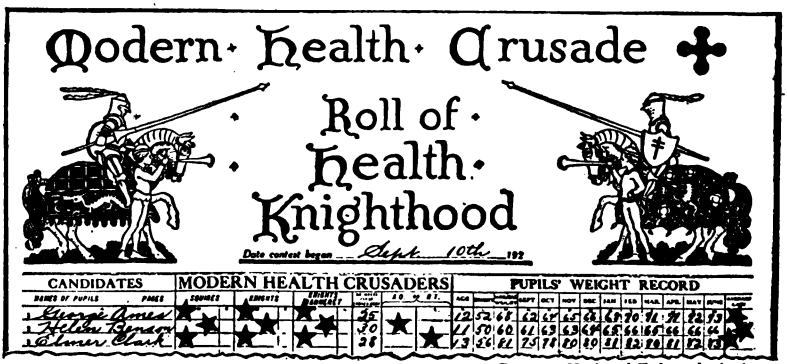
Courtesy National Tuberculosis Assn.
THIS IS A REPRODUCTION OF THE PIN WORN BY A KNIGHT BANNERET.

Every boy or girl not already a Modern Health Crusader should obtain a set of health rules from the National Tuberculosis Association and should keep either at home or at school a record of "health chores" till he or she is a Knight Banneret and has firmly fixed the habits of healthful daily living.

Boy Scouts and Camp Fire Girls should be Health Crusaders

If you are a Boy Scout or a Camp Fire Girl, you know that you must also be a Health Crusader. No boy can be a real Boy Scout who does not try to develop and keep a good, healthy body so that he will feel well and be ready for hikes, games, plays, and tasks that Boy Scouts should perform. No girl can be a good Camp Fire Girl unless she can take part in the out-of-door

life, — swimming, camping, hikes into the country and into the woods, — which all Camp Fire Girls should enjoy. Do you not see that the reason why we should keep healthy and strong is so that we may do all the things that our companions can do and be a help in the world, not a hindrance? This will make



Courtesy National Tuberculosis Assn.

THIS SHOWS PART OF A SCHOOL ROLL OF HEALTH.

life happier for ourselves and more agreeable for all those with whom we have any relations.

Standards or norms in bodily development and health habits

How can one tell whether he is as healthy and strong as he should be? I am going to tell you how you can determine whether you have as good a body and as fine health as you should have. By examining hundreds of thousands of boys and girl of all ages, and keeping a careful daily account of their health, it has been possible to show what a healthy body should be at different ages. You will find it very useful to compare your body with the *standard* or *norm;* the standard or norm shows the kind of body which thoroughly sound and healthy people of your age should possess. In order that you may see how you rank in health, you should make out a chart and indi-

cate how you stand in regard to every important point of bodily development and health. Your teacher will help you to make this chart, and when it is made you should show it to her, and then show it to your parents and keep it as a record. You

RIGHT HEIGHT and WEIGHT FOR BOYS

Height Inches	5 Yrs.	6 Yrs.	7 Yrs.	8 Yrs.	9 Yrs.	10 Yrs.	11 Yrs.	12 Yrs.	13 Yrs.	14 Yrs.	15 Yrs.	16 Yrs.	17 Yrs.	18 Yrs.
39	35													
40	37	38												
41	39	40												
42	41	42												
43	43	44	44											
44	45	45	46											
45	....	47	47	48										
46	....	49	50	50										
47	....	....	51	52	52									
48	....	....	53	54	55									
49	....	....	....	55	56	57								
50	....	....	....	58	59	59								
51	....	....	....	60	61	62	62							
52	....	....	....	....	64	65	65							
53	....	....	....	....	67	68	68	68						
54	....	....	....	....	70	71	71	72						
55	....	....	....	....	....	74	75	76	76					
56	....	....	....	....	....	77	79	79	80					
57	....	....	....	....	....	....	81	82	83	84				
58	....	....	....	....	....	....	84	85	87	88				
59	....	....	....	....	....	....	....	88	89	91	92			
60	....	....	....	....	....	....	....	90	92	94	95			
61	....	....	....	....	....	....	....	....	97	99	100	101		
62	....	....	....	....	....	....	....	....	100	102	104	105		
63	....	....	....	....	....	....	....	....	104	106	108	109	110	
64	....	....	....	....	....	....	....	....	....	112	113	115	117	120
65	....	....	....	....	....	....	....	....	....	118	119	121	122	123
66	....	....	....	....	....	....	....	....	....	....	123	124	125	127
67	....	....	....	....	....	....	....	....	....	....	125	126	127	131
68	....	....	....	....	....	....	....	....	....	....	130	131	133	136
69	....	....	....	....	....	....	....	....	....	....	....	134	136	139
70	....	....	....	....	....	....	....	....	....	....	....	136	140	143
71	....	....	....	....	....	....	....	....	....	....	....	....	142	145

Health in Education
Education in Health

PREPARED BY DR. THOMAS D. WOOD

Courtesy of Child Health Organization

should use some such title as this title for your chart: "How I Stand in Health Matters."

First, you should see how you compare with the standard or norm in regard to weight. Examine the table for boys or for

girls to find what you should weigh for your height at different ages. You are not responsible for your height, but you are largely responsible for your weight; and you can control it. If you weigh five pounds more or five pounds less than the

RIGHT HEIGHT and WEIGHT FOR GIRLS

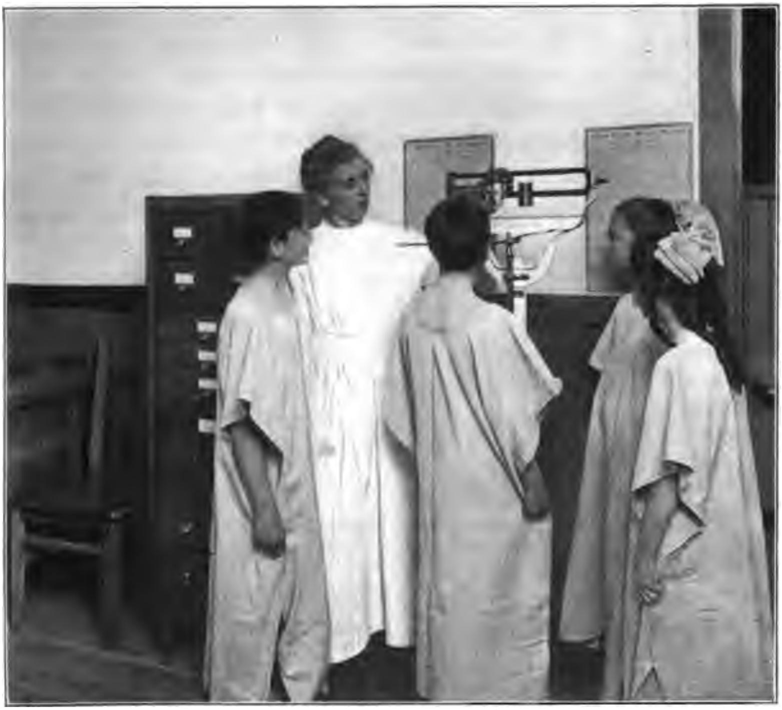
Height Inches	5 Yrs.	6 Yrs.	7 Yrs.	8 Yrs.	9 Yrs.	10 Yrs.	11 Yrs.	12 Yrs.	13 Yrs.	14 Yrs.	15 Yrs.	16 Yrs.	17 Yrs.	18 Yrs.
39	34													
40	35	37												
41	39	39												
42	41	42	42											
43	43	44	44											
44	45	46	46											
45	....	47	47	47										
46	....	48	49	50										
47	....	....	50	51	53									
48	....	....	52	53	54									
49	....	....	....	55	56	57								
50	....	....	....	57	59	60								
51	....	....	....	....	61	62	63							
52	....	....	....	....	65	66	67							
53	....	....	....	....	....	68	68	69						
54	....	....	....	....	....	70	71	71						
55	....	....	....	....	....	....	72	73	74					
56	....	....	....	....	....	....	76	77	77	79				
57	....	....	....	....	....	....	....	79	82	85				
58	....	....	....	....	....	....	....	85	88	93	96			
59	....	....	....	....	....	....	....	....	92	95	100	105		
60	....	....	....	....	....	....	....	....	97	99	103	107	109	
61	....	....	....	....	....	....	....	....	99	102	105	109	111	
62	....	....	....	....	....	....	....	....	....	105	107	111	113	116
63	....	....	....	....	....	....	....	....	....	107	110	113	115	117
64	....	....	....	....	....	....	....	....	....	....	114	117	119	121
65	....	....	....	....	....	....	....	....	....	....	....	121	123	125

PREPARED BY DR. THOMAS D. WOOD

Courtesy of Child Health Organization

norm for your age, your record may be considered *excellent* (use E in marking). If you weigh seven pounds more or less than the norm, your record may be considered *good* (use G in marking). If you weigh ten pounds more or less, your rec-

ord is *fair* (use F in marking). If you weigh fifteen pounds more or less, your record is *poor* (use P in marking). If you weigh twenty pounds more or less than the standard, your record is *very poor* (use V P in marking).



Courtesy National Tuberculosis Assn.

THESE BOYS AND GIRLS ARE BEING WEIGHED BY THE SCHOOL NURSE.

Standard weight for height

If your record is not excellent in respect to weight, you should find out what is the matter. If you have excess weight, you are probably eating too much, perhaps too many sweets. It may be that you eat between meals and so consume more food than you need. Perhaps you

do not exercise enough. If you will study the matter, you can find out why you are too heavy for your height. If you carry around excess weight, it is a burden on your heart, and you are less fit for any task or game than you should be.

If you do not weigh enough, you should find out whether you are eating the proper foods, and the right amount of each. You may be drinking tea or coffee, which make most children very nervous so that they lose weight and feel badly in many ways. You may not have well-balanced meals. You may be getting to bed too late so that you are not well-rested. You may not have formed regular habits in regard to getting rid of body waste. This is a very bad habit and is the cause of much ill health.

Regulating one's meals according to one's weight

You can see what well-balanced meals are and about what amounts of each article you should eat if you will study the following list of sample meals for different seasons prepared by United States government specialists. You can vary the amounts of each article according as you are underweight or overweight. If you can secure good, wholesome milk, you may drink an additional glass at each meal provided you are not overweight. You may always substitute eggs for meat if you like them. You may add lettuce and celery to every dinner and supper whenever you can secure them. Whole wheat or graham bread is better than white bread.

Sample Summer Diet for a Week for Children of 7 to 14 Years

Breakfast.	Dinner.	Supper.
Oatmeal, ½ to ¾ cup, with milk. Stewed fruit, 2 to 3 tablespoonfuls. Bread and butter, 2 to 3 slices. Milk to drink, 1 glass.	Lamb stew, with vegetables, small portion. Squash or string beans, 2 to 3 tablespoonfuls. Bread and butter, 2 to 3 slices. Bread pudding, 2 tablespoonfuls.	Potato soup, with milk, 1 cup. Poached egg on toast. Brown bread and butter, 2 to 3 slices Stewed prunes, 4 to 5. Milk to drink, 1 glass.

Sample Summer Diet — *Continued.*

Breakfast.	Dinner.	Supper.
Force or corn flakes, 1 cup, with milk. Egg. Brown bread and butter, 2 to 3 slices. Milk to drink, 1 glass.	Chicken with rice, small portion. Mashed potatoes, 2 to 3 tablespoonfuls. Dandelion greens, or boiled onions, 2 to 3 tablespoonfuls. Stewed fruit, 2 to 3 tablespoonfuls. Bread and butter, 2 to 3 slices.	Spinach soup with milk, 1 cup. Corn bread and sirup, 2 to 3 pieces. Cottage cheese, 1 level tablespoonful. Ginger cookies, 1.
Hominy, ½ to ¾ cup, with milk. Toast and butter, 2 to 3 slices. Baked banana, 1. Milk to drink, 1 glass.	Bacon, 1 slice. Poached egg and spinach. Spaghetti with tomatoes, 2 to 3 tablespoonfuls. Green peas or string beans, 2 to 3 tablespoonfuls. Bread and butter, 1 to 2 slices.	Corn flakes, 1 to 2 cups, with milk. Purée of lima beans, ¾ cup. Ginger cookies, 1 to 2. Milk to drink, 1 glass.
Corn meal, ½ to ¾ cup, with sirup. Scrambled egg, 1. Bread and butter, 2 to 3 slices. Milk to drink, 1 glass.	Rice pudding, 1 to 2 tablespoonfuls. Hamburg steak, 1 small ball. Stewed potatoes, 2 to 3 tablespoonfuls. New beets and beet-top greens, 2 to 3 tablespoonfuls. Stewed fruit, 2 to 3 tablespoonfuls. Bread and butter, 2 to 3 slices.	Milk toast or rice, ½ cup, with milk. Baked potato, 1. Bread and butter, 2 to 3 slices. Milk to drink, 1 glass.
Shredded wheat, 1, with milk. Corn bread and butter, 2 pieces. Apple sauce or stewed pear, 2 to 3 tablespoonfuls. Milk to drink, 1 glass.	Fish or clam chowder, ¾ cup, or egg. New beets or spinach, 2 to 3 tablespoonfuls. Boiled potato. Bread and butter, 2 to 3 slices. Custard or junket, ½ cup.	Oatmeal soup, 1 cup. Squash, chard, or carrots, 2 to 3 tablespoonfuls. Stewed fruit, 2 to 4 tablespoonfuls. Bread and butter, 2 slices. Milk to drink, 1 glass. Plain cookies, 1.
Force or corn flakes, 1 to 2 cups, with milk. Poached egg on toast. Brown bread and butter, 2 to 3 slices. Milk to drink, 1 glass.	Lamb hash or veal cutlet, small portion. String beans, 2 tablespoonfuls. Baked potato. Bread and butter, 2 to 3 slices. Apple sauce, 2 to 4 tablespoonfuls.	Rice and milk, ¾ cup. Corn bread and butter, 2 slices. Ginger cookies, 1 to 2. Milk to drink, 1 glass.

SAMPLE SUMMER DIET — *Continued.*

BREAKFAST.	DINNER.	SUPPER.
Rice, ½ cup, with milk. Bread and butter, 2 to 3 slices. Stewed fruit, 2 to 3 tablespoonfuls. Milk to drink, 1 glass.	Dried pea or bean soup, 1 cup. Baked potato. Bread and butter, 2 to 3 slices. Lima beans or new beets, 2 tablespoonfuls. Ice cream or fruit sherbet, 2 tablespoonfuls.	Baked potato, 1. Poached egg on toast, 1. Stewed prunes, 4 to 5. Plain cookies, 1 to 2. Milk, 1 glass.

For the younger children use more milk and less meat.

SAMPLE WINTER DIET FOR A WEEK FOR CHILDREN OF 7 TO 14 YEARS.

BREAKFAST.	DINNER.	SUPPER.
Oatmeal, ⅔ cup, with milk. Bread and butter, 2 to 3 slices. Baked apple, 1. Milk to drink, 1 glass.	Roast lamb, small slice; baked potatoes. Beets, onions, or oyster plant, 2 to 3 tablespoonfuls. Rice pudding, 2 to 3 tablespoonfuls. Bread and butter, 2 to 3 slices.	Scrambled egg, 1. Bread and butter, 2 to 3 slices. Oatmeal cookies, 1 to 2. Milk to drink, 1 glass.
Hominy, ⅔ cup, with milk. Bread and butter, 2 to 3 slices. Bacon, 1 slice. Cocoa with milk, 1 cup.	Vegetable soup, with carrots, beans, onions, 1 cup. Spinach with poached egg,[1] 2 to 3 tablespoonfuls. Corn bread and butter, 2 to 3 slices. Dates, 4 to 5.	Baked potato, 1. Bread and butter, 2 to 3 slices. Stewed apricots, 2 to 3 tablespoonfuls. Cottage cheese,[1] 1 tablespoonful.
Corn meal, ½ to ⅔ cup, with milk. Toast and butter, 2 to 3 slices. Apple sauce, 2 to 4 tablespoonfuls. Milk to drink, 1 glass.	Rice and meat loaf, small portion. Stewed celery and cauliflower, 2 to 3 tablespoonfuls. Bread and butter, 2 to 3 slices. Baked Indian pudding, 2 tablespoonfuls.	Rice and milk, ½ cup. Baked banana, 1. Fruit cookies, 1 to 2. Bread and butter, 3 to 4 slices.

[1] Toward spring, when eggs are abundant, they may be given more frequently, replacing some meat and milk. Cottage cheese should be made at home or the best grade purchased and used only when fresh.

SAMPLE WINTER DIET — *Continued.*

BREAKFAST.	DINNER.	SUPPER.
Oatmeal, ¾ cup, with milk. Bread and butter, 2 to 3 slices. Stewed prunes or figs, 3 to 4. Cocoa with milk, 1 glass.	Beef stew with vegetables, small portion. Bread and butter, 3 to 4 slices. Rice pudding or custard, 2 to 3 tablespoonfuls.	Corn bread and sirup, 2 to 3 pieces. Soft egg. Bread, 2 to 3 slices, and peanut butter, ½ tablespoonful. Cocoa with milk, 1 glass.
Force or corn flakes, 1 to 2 cups, and milk. Bread and butter, 2 to 3 slices. Soft egg and bacon, 1. Milk to drink, 1 glass.	Chicken, small slice; potato soup with milk, 2 to 3 cups. Creamed carrots or onions, 2 to 3 tablespoonfuls. Gingerbread and thin cream, 1 small piece. Bread and butter, 2 to 3 slices.	Milk toast, 2 to 3 slices. Cottage cheese, 1 tablespoonful. Stewed prunes, 4 to 5. Cookies; milk to drink, 1 glass.
Pettijohn or malt breakfast food, ¾ cup, with milk. Bread and butter, 2 to 3 slices. Soft egg; milk to drink, 1 glass.	Creamed or fresh broiled fish, small portion. Baked apple, 1. Bread and butter, 2 to 3 slices.	Spinach or bean soup, 1 cup. Baked potato, 1. Corn bread and butter, 2 pieces. Milk to drink, 1 glass.
Corn meal, ¾ cup, and milk. Toast and butter, 2 to 3 slices. Stewed dried peaches, 2 to 3 tablespoonfuls. Cocoa with milk, 1 cup.	Lamb stew, with vegetables, small portion. Baked sweet potato, 1. Boiled potato, 1. Bread or rice pudding, 2 to 3 tablespoonfuls. Bread and butter, 2 to 3 slices.	Celery soup with milk, 1 cup. Bread and butter, 2 to 3 slices. Custard or junket, ½ cup. Ginger cookies, 1 to 2; milk to drink, 1 glass.

Scoring one's eyesight

You have been learning how to make your weight conform to the standard for your age. You need to compare yourself with the standard or norm in respect to other matters also. You must have your eyes examined. You should be able to see letters of a certain height and thickness clearly at a given distance. An oculist should make the examination. He will tell you whether you have *excellent*, *good*, *fair*, or *poor* eyes. If you have anything but excellent eyes and do not wear glasses that correct the defect, you must score yourself on your chart to show that you are not up to standard.

Scoring one's hearing and breathing

You should be able to hear, with each ear, the ticking of an ordinary watch at a distance of five or six feet. If you have to bring it as close as three feet, you have *poor* hearing. Your physician can perhaps discover the cause for this and remove it You should score yourself also in regard to breathing. If the nasal passages are not free and clear so that you can breathe through them at all times, even when you are running hard, your breathing is not

UNLESS THESE BOYS RECEIVE ATTENTION FROM A CAPABLE DENTIST THEY WILL BE SERIOUSLY HANDICAPPED IN THE RACE OF LIFE. HEALTH IS INJURED AND THE APPEARANCE MARRED BY DECAYING OR ILL-FORMED TEETH.

excellent. If you breathe through the mouth frequently, you should score your breathing as *poor*. You should have a physician examine you to see if you have adenoids or enlarged tonsils. If you have either, you must score your breathing as *poor*,

because they will interfere with it. If you have both, your score is *very poor*. A surgeon could very quickly and easily make you *good* or *excellent* in respect to these matters.

Scoring in regard to teeth

You must score yourself in regard to teeth. If your teeth are all sound and clean, you should score yourself *excellent* in that respect. If you have several teeth that are decaying, score your teeth *poor*. If you have any aching teeth that have not been treated by a dentist, you must score *very poor*. You can very easily change your record from *very poor* to *excellent* if you will visit a good dentist. If your teeth are dirty, you must not score yourself higher than *fair* until they are clean.

Enlarged glands

Next, you should see if you have any enlarged glands. You have learned that the proper working of these glands is very important for good health. If you have one enlarged gland, your score is *poor;* if more, *very poor*.

Spinal curvature

Your spinal column should be examined by your physical culture teacher or a physician, and if you have any spinal curvature your score is *very poor*. You can have this corrected readily if you do not wait until it is too late.

Chest development and expansion

You must score your chest development. Your physical training teacher will measure different parts of your chest and tell you whether your development is *excellent*, *good*, *fair*, or *poor*. If it is found to be *poor*, you can easily change your score to *good* or *excellent* by exercises which will develop the chest. Deep breathing exercises will increase your expansion. A good chest expansion is very important.

Sound lungs

You know that sound lungs are absolutely necessary for good health. A physician can tell you very quickly whether any part of either of your lungs is undeveloped or diseased. If you do not score *excellent* in regard to lungs,

you can probably discover why you are deficient, and so change your habits that you will be able to improve your score.

The arch of the foot You should have the arch of the foot examined. Some people have what is known as "broken arch." This is bad for the health. It can be corrected if taken in time.

Here is the chart, then, for scoring yourself in regard to a healthy body.

	1ST Mo.	2ND Mo.	3RD Mo.	4TH Mo.	5TH Mo.	6TH Mo.	7TH Mo.	8TH Mo.	9TH Mo.
1. Weight									
2. Eyes									
3. Ears									
4. Breathing . . .									
5. Teeth									
6. Glands									
7. Spinal column . .									
8. Chest development									
9. Lungs									
10. Arch of foot . . .									

In the Modern Crusade Movement, there is an honor higher than becoming Knight Banneret. It is to be a *Knight of the Round Table*. Crusaders earn points toward winning a seat at the round table through such tests for physical fitness as you have just read about,—tests for good weight, good eyesight, hearing, posture, and the other qualifications. What a fine country we should have if all the boys and girls in it were fit to be Knights of the Round Table!

APPENDIX

Tables of Composition of Foods

You should keep the following tables for reference, so that you can tell what nutrients are to be found in all the ordinary foods. The meaning of the figures in these tables is clear when you remember that for every 100 pounds of milk, 87.0 pounds are water, 3.3 pounds are protein, etc.

Protein Foods — Composition

Food	Water	Protein	Fat	Carbohydrates	Ash Mineral
Milk	87.0	3.3	4.0	5.0	0.7
Eggs	73.7	14 8	10.5		1.0
Cheese	34.0	24.3	33.4	4.5	3.8
Fowl	63.7	19.3	16.3		1.0
Beef	61.9	18.6	18.5		1.0
Fish (lean)	82.6	15.8	0.4		1.2

U. S. Department of Agriculture.

General Composition of Grains

Grains	Water	Protein	Fat	Carbohydrates	Cellulose	Ash Mineral
Bread, Graham (whole meal)	35.7	8.9	1.8	52.1	1.1	1.5
Macaroni	13.1	9.0	0.3	76.8		0.8
Wheat	11.4	13.8	1.9	71.9	0.9	1.0
Oats (meal)	7.3	16.1	7.2	67.5	0.9	1.9
Barley	11.5	8.5	1.1	77.8	0.3	1.1
Corn (green)	75.4	3.1	1.1	19.7	0.5	0.7
Rice	0.3	8.0	0.3	79.0	0.2	0.4

General Composition of Fruits

Edible Portion Fruit	Water	Protein	Fat	Carbohydrates	Cellulose	Ash Mineral
Gooseberries	85.6	1.0		13.1		0.3
Currants	85.0	1.5		12.8		0.7
Whortleberries	82.4	0.7	3.0	13.5	3.2	0.4
Blueberries } Cranberries }	88.9	0.4	0.6	9.9	1.5	0.2
Grapes	77.4	1.3	1.6	19.2	4.3	0.5
Blackberries	86.3	1.3	1.0	10.9	2.5	0.5
Raspberries (blk.)	84.1	1.7	1.0	12.6		0.6
Strawberries	90.4	1.0	0.6	7.4	1.4	0.6
Melons	89.5	0.6		9.3	2.1	0.6
Watermelons	92.4	0.4	0.2	6.7		0.3
Pineapples	89.3	0.4	0.3	9.7	0.4	0.3
Bananas	75.3	1.3	0.6	22.0	1.0	0.8
Apples	84.6	0.4	0.5	14.2	1.2	0.3
Pears	84.4	0.6	0.5	14.1	2.7	0.4
Peaches	89.4	0.7	0.1	9.4	3.6	0.4
Plums	78.4	1.0		20.1		0.5
Cherries	80.9	1.0	0.8	16.7	0.2	0.6
Oranges	86.9	0.8	0.2	11.6		0.5
Dates (dried)	15.4	2.1	2.8	78.4		1.3
Figs (dried)	18.8	4.3	0.3	74.2		2.4
Prunes (dried)	22.3	2.1		73.3		2.4
Raisins (dried)	14.6	2.6	3.3	76.1		3.4
Olives	67.0	2.5		9.0		4.4

The Composition of Legumes

Legumes	Water	Protein	Fat	Carbohydrates	Cellulose	Ash Mineral
Lima beans (dried)	10.4	18.1	1.5	65.9		4.1
String beans	89.2	2.3	.3	7.4	1.9	.8
Green peas	74.6	7.0	.5	16.9	1.7	1.0
Peas (dried)	9.5	24.6	1.0	62.0	4.5	2.9
Lentils (dried)	8.4	25.7	1.0	59.2		5.7
Beans (dried)	12.6	22.5	1.8	59.6	4.4	3.5

General Composition of Nuts

Edible Portion Nuts	Water	Protein	Fat	Carbohydrates	Cellulose	Ash Mineral
Coconuts	14.1	5.7	50.6	27.9		1.7
Almonds	4.8	21.0	54.9	17.3	2.0	2.0
Pecans	2.7	9.6	70.5	15.3		1.9
Hickory nuts	3.7	15.4	67.4	11.4		2.1
Filberts	3.7	15.6	65.3	13.0		2.4
Brazil nuts	5.3	17.0	66.8	7.0		3.9
Chestnuts	45.0	6.2	5.4	42.1	1.8	1.3
Walnuts (black)	2.5	27.6	56.3	11.7	1.7	1.9
Peanuts	9.2	25.8	38.6	24.4	2.5	2.0

General Composition of Vegetables

Edible Portion Vegetables	Water	Protein	Fat	Carbohydrates	Cellulose	Ash Mineral
Potatoes	78.3	2.2	0.1	18.4	0.4	1.0
Sweet potatoes	69.0	1.8	0.7	27.4	1.3	1.1
Carrots	88.2	1.1	0.4	9.3	1.1	1.0
Turnips	89.6	1.3	0.2	8.1	1.3	0.8
Radishes	91.8	1.3	0.1	5.8	0.7	1.0
Beets	87.5	1.6	0.1	9.7	0.9	1.1
Parsnips	83.0	1.6	0.5	13.5	2.5	1.4
Cabbage	91.5	1.6	0.3	5.6	1.1	1.0
Cauliflower	92.3	1.8	0.5	4.7	1.1	0.7
Spinach	92.3	2.1	0.3	3.2	0.9	2.1
Celery	94.5	1.1	0.1	3.3		0.1
Asparagus	94.0	1.8	0.2	3.3	0.8	0.7
Cucumber	95.4	0.8	0.2	3.1	0.7	0.5
Tomatoes	94.3	0.9	0.4	3.9	0.6	0.5
Squash	88.3	1.4	0.5	9.0	0.8	0.8
Onions	87.6	1.6	0.3	9.9	0.8	0.6

General Composition of Fats

Fats	Water	Proteid	Fat	Carbo-hydrates	Ash Mineral
Butter	11.0	1.0	85.0		3.0
Olive Oil			100.0		
Cream	74.0	2.5	18.5	4.5	0.5

Average Composition of Foods

	Fruit	Nuts	Legumes
Water	85–90%	4–5%	10–14.20%
Proteid	5%	15–20%	13.81–25.16%
Fat	.05%	50–60%	0.58–2.46%
Carbohydrates	5½–10½%	9–12%	52–12%
Cellulose	2½%	3–5%	2–3%
Mineral matter	.05%	1%	

GLOSSARY

KEY TO PRONUNCIATION

ā, as in **āle**; **ȧ**, as in **sen′ȧte**; **â**, as in **câre**; **ă**, as in **ăm**; **ä**, as in **ärm**; **ȧ**, as in **ȧsk**; **ạ**, as in **ạll**; *a*, as in **fi′n*a*l**; **ē**, as in **ēve**; **ė**, as in **ė-vent′**; **ĕ**, as in **ĕnd**; **ẽ**, as in **fẽrn**; *e*, as in **re′c*e*nt**; **ī**, as in **īce**; **ı̇**, as in **ı̇-de′a**; **ĭ**, as in **ĭll**; **ō**, as in **ōld**; **ȯ**, as in **ȯ-bey′**; **ô**, as in **ôrb**; **ŏ**, as in **ŏdd**; **ū**, as in **ūse**; **u̇**, as in **u̇-nite′**; **ŭ**, as in **ŭp**; **û**, as in **ûrn**; **y̆**, as in **pit′y̆**; **o͞o**, as in **fo͞od**; **o͝o**, as in **fo͝ot**; **ou**, as in **out**; **oi**, as in **oil**.

A

abdominal cavity (ăb-dŏm′ĭ-nal kăv′ĭ-ty̆). The hollow place in the body in which the organs of the abdomen are situated.

abscess (ăb′sĕs). A collection of pus in any tissue or organ of the body, due to infection.

abstinence (ăb′stĭ-n*e*ns). The act, or practice, of denying oneself, particularly as applied to drinking alcoholic beverages and to smoking.

acetanilid (ăs′ĕt-ăn′ĭ-lĭd or -līd). A medicinal compound of aniline with acetyl, used to relieve fever or pain, but dangerous when used without a physician's order.

adenoids (ăd′ė-noids). Growths that form in the nasal passages and interfere with breathing.

albumen (ăl-bū′mĕn). One element of food, found in the white of an egg and elsewhere.

alimentary canal (ăl′ĭ-mĕn′tȧ-ry̆ kȧ-năl′). The whole length of the food channel extending through the body.

alkalinity (ăl′kȧ-lĭn′ĭ-ty̆). Having the quality of an alkaline substance; that is, a substance like soda, opposed to acidity.

amœba (ȧ-mē′bȧ). A tiny animal that consists of just one cell.

anæmia (ȧ-nē′mĭ-ȧ). An unhealthy condition of the blood, in which there is too little blood in the body or in which the blood itself is lacking in some essential quality.

analogous (ȧ-năl′ō̍-gŭs). Having a likeness to something else.

anterior chamber (ăn-tē′rĭ-ẽr chām′bẽr). The inclosed space in the eye in front of the lens.

antiseptic (ăn′tĭ-sĕp′tĭc). Anything, usually a liquid, that prevents decay or that protects one from germs.

anvil (ăn′vĭl). One of the three small bones in the ear. This bone has a shape like that of a blacksmith's anvil.

aorta (ā̍-ôr′tȧ). The great artery which carries the blood from the heart to all parts of the body except to the lungs; the main trunk of the arterial system.

apex (ā′pĕks). The tip, point, of anything; as the *apex* of the heart.

apoplexy (ăp′ō̍-plĕks′y̆). The pressure of blood in the brain, which causes a blood vessel to burst.

aqueous humor (ā′kwē̍-ŭs hū′mẽr). A fluid in the eye which fills the anterior chamber.

arterioles (är-tē′rĭ-ōlz). Very small arteries.

arterio-sclerosis (är-tē′rĭ-ō-sklē̍-rō′sĭs). The hardening of the arteries, due usually to bad habits of living in respect to eating, drinking, and smoking.

assimilation (ăs-sĭm′ĭ-lā′shŭn). The process of changing blood into tissues and organs.

auditory canal (ạ′dĭ-tō̍-ry̆ kȧ-năl′). The tube from the opening of the ear to the drum of the ear.

auricle (ạ′rĭ-k'l). One of the compartments in the heart that receives the blood from the veins. Its name comes from its likeness to the outside ear.

B

bacillus (ba-sil′us). A tiny vegetable organism often the cause of disease; a variety of bacterium.

bacteria (bȧk-tē′rĭ-ă). The plural of *bacterium*. Tiny plants that grow in the body. Some are harmful; some helpful.

bicuspids (bī-kŭs′pids). The two double-pointed teeth which grow, one on each side of the jaw, between the cuspids and the molars.

bile (bīl). A yellow or greenish fluid found in the liver.

biliousness (bĭl′yŭs-nĕs). The state of the body when there is too much bile in the system.

bismuth (bĭz′mŭth). A substance sometimes administered to indicate, under the X-ray, the course which food takes in the alimentary canal.

bronchi (brŏn'kī). The plural of *bronchus*. The tubes that carry the air from the windpipe into the lungs.

bronchioles (brŏn'kĭ-ōles). Tiny bronchial tubes.

C

caffeine (kaf-fēn'). A white, bitter substance found in coffee; a poison.

calorie (kăl'ō-ri). A unit of heat. Just as in measuring a straight line, we begin with the inch, so in measuring heat, we begin with the calorie.

capillary (kăp'ĭl-lā-rȳ or kȧ-pĭl'lȧ-rȳ). A tiny thin-walled tube; particularly one of the smallest blood vessels connecting arteries and veins.

carbohydrates (kär'bō-hī'drāts). Food elements, including principally sugars and starches.

carbonic acid gas (kär-bŏn'ĭk ăs'ĭd găs). The substance which a plant takes from the air and which is thrown off from the lungs of animals in breathing.

cardiac (kär'dĭ-ăk). Pertaining to the heart.

cartilage (kär'tĭ-lāj). An elastic tissue found mainly in the body between joints and at the ends of bones.

cell (sĕl). One of the tiny structures that compose the greater part of the tissues and organs of the body.

cellulose (sĕl'ū-lōs'). The delicate framework that remains when the soluble part of starch is removed by saliva or pepsin.

centenarian (sĕn'tē-nā'rĭ-*a*n). A person one hundred years old or more.

centigrade (sĕn'tĭ-grād). Consisting of one hundred degrees; used to describe a thermometer on which the freezing point of water is 0° and the boiling point is 100°.

cerebellum (sĕr'ē-bĕl'lŭm). The little brain. It controls the action of the muscles.

cerebrum (sĕr'ē-brŭm). The larger division of the brain. It is concerned in reasoning and willing.

choroid (kō'roid). The middle coat of the eyeball.

chronic (krŏn'ĭk). Continuing for a long time; lingering; habitual.

chyme (kīm). The name given to food we have eaten when it is a half-digested, pulpy mass. The food is in this state in the small intestine.

cilia (sĭl'ĭ-ȧ). The plural of *cilium*, which is rarely used. Tiny hairs in the air passages, especially the nostrils.

circular muscles (ser′ku-lar mŭs″les). The muscles that go *around* an organ or an opening.

clot (klŏt). A thickened, congealed mass; as, a *clot* of blood.

cocaine (kō′kȧ-ĭn). A substance used to deaden pain; a poison.

cochlea (kŏk′lē-ȧ). The part of the ear at the entrance of the inner ear.

colic (kŏl′ĭk). A severe pain in the abdomen.

colon (kō′lŏn). A part of the large intestine.

coma (kō′ma). A state of unconsciousness from which it is difficult or impossible to arouse a person.

combustion (kŏm-bŭs′chŭn). The process of burning.

contaminated (kŏn-tăm′ĭ-nā′tĕd). Made foul; polluted; stained; soiled; dangerous; as when milk or water is contaminated by germs of typhoid or other diseases.

convolutions (kŏn′vō-lū′shŭnz). Irregular winding folds of an organ; as, the *convolutions* of the brain; the *convolutions* of the intestines.

cornea (kôr′nē-ȧ). The part of the coat of the eyeball which covers the iris and the pupil and lets in light to the inside of the eye.

corpulence (kôr′pū-lens). Excessive amount of fat; fleshiness.

cortex (kôr′tĕks). The outer part of an organ; as the *cortex* of the brain, which is composed of the outer layers of nerve cells.

cranium (krā′nĭ-ŭm). The skull; the bony case for the brain.

crystalline lens (krĭs′tal-lĭn or -lĭn lĕnz). The part of the eye that brings the rays of light to a point.

cuspids (kŭs′pĭdz). The teeth that have but one point (or cusp) on the crown.

D

dermis (dẽr′mĭs). The layer of skin beneath the scarfskin or epidermis.

diaphragm (dī′ȧ-frăm). The muscle that separates the cavity of the chest from that of the abdomen.

dietary (dī′ĕt-ā-rȳ). Pertaining to diet; that is, to the amount and kind of food one eats.

digestion (dĭ-jĕs′chŭn). The changing of foods into such form that the blood can absorb the useful parts and the body throw off the useless parts.

dilate (dĭ-lāt′ or dī-lāt′). To enlarge; to swell; to expand.

duct (dŭkt). A tube or canal.

E

emulsified (ē-mŭl′sĭ-fīd). Subdivided into tiny particles of fat; reduced from an oily substance to a milky fluid, as when olive oil is blended with lemon juice.

endurance (ĕn-dūr′*a*ns). The quality of being able to keep up an exertion, or to bear pain, for a considerable length of time.

enzyme (ĕn′zīm). A substance made by the salivary glands, which causes fermentation and is necessary for the digestion of starch.

epidermis (ĕp′ĭ-dẽr′mĭs). The outer layer of the skin; the scarfskin.

epiglottis (ĕp-ĭ-glŏt′tĭs). The lid-like covering which closes the glottis while food or drink passes through the pharynx.

epithelial cells (ĕp′ĭ-thē′lĭ-al sĕlz). Cells that cover the surface of the body and line all the cavities of the body.

epithelium (ĕp-ĭ-thē′lĭ-ŭm). The covering formed by the epithelial cells.

esophagus (ē-sŏf′ȧ-gŭs). The part of the alimentary canal between the pharynx and the stomach; the gullet.

eustachian tube (ū-stä′kĭ-an tūb). The tube that leads from the eardrum to the pharynx.

excrete (ĕks-krēt′). To cast off from the body as useless.

excretion (ĕks-krē′shun). The act of throwing off; the discharging of wastes from the body.

extensors (ĕks-tĕn′sŏrz). Muscles that serve to extend or straighten any part of the body, as an arm or a finger; opposed to *flexors*, which bend or contract muscles.

F

fatty degeneration (făt′ty dē-jĕn′ẽr-ā′shŭn). A diseased condition, in which the presence of too much fat interferes with the working of the organs.

fermentation (fẽr′mĕn-tā′shŭn). A change in a substance due to the action of bacteria; usually gas is formed, and alcohol also in greater or less quantities.

fiber (fī′bẽr). One of the delicate, thread-like portions of which the tissues of plants and animals are in part made up.

fissures (fĭsh′urz). Furrows or depressions, as in the surface of the brain.

flexors (flĕks'ŏrz). Muscles which bend (flex) any part; opposed to *extensors*.

frontal lobes (frŏn'tal lōbz). The round projecting parts of the brain in front.

G

gall bladder (ga̤l blăd'dẽr). The sac in which gall is stored up.

gastric juice (găs'trĭk jūs). A thin watery fluid of an acid nature that flows from the walls of the stomach to mix with the food and aid digestion.

germicide (jẽr'mĭ-sīd). Anything that kills germs.

glottis (glŏt'tĭs). The opening from the pharynx into the larynx or into the trachea.

glycogen (glī'kō-jĕn). Digested starch stored in the body.

gossamer (gŏs'sȧ-mẽr). Any very thin gauze-like fabric; a fine, filmy substance like cobwebs.

granule (grăn'ūl). A little grain; a small particle; a pellet.

gullet (gŭl'lĕt). The tube by which food is carried from the pharynx to the stomach; the esophagus.

H

hæmoglobin or **hemoglobin** (hĕm'ō-glō'bĭn or hē'mō-glō'bĭn). The coloring matter of the red blood corpuscles.

hair follicle (hâr fŏl'lĭ-k'l). A small cavity, or depression, at the outer end of a tiny tube, from which a hair grows.

hammer (hăm'mẽr). One of the three small bones in the ear. It gets its name from its likeness to a hammer.

hydrochloric acid (hī'drō-klō'rĭk ăs'ĭd). An acid contained in the gastric juice.

I

incapacitated (ĭn'kȧ-păs'ĭ-tāt-ĕd). Deprived of natural power; disabled.

incisors (ĭn-sī'zẽrz). The teeth in front of the canines, or cuspids. They are used especially for cutting food.

infection (ĭn-fĕk'shŭn). Disease caused by germs; also the giving of disease germs to a well person by a diseased one.

inorganic (ĭn'ôr-găn'ĭk). Without the organs necessary for life; lifeless.

insoluble (ĭn-sŏl'ū-b'l). Incapable of being dissolved by a liquid; as, chalk is *insoluble* in water.

insomnia (ĭn-sŏm′nĭ-ȧ). Inability to sleep; wakefulness; sleeplessness.

intestines (ĭn-tĕs′tĭnz). All of the alimentary canal from the stomach downward.

iris (ī′rĭs). The movable, muscular curtain lined with dark pigment found in the eye.

J

jaundice (jän′dĭs). A disease in which the eyes and skin turn yellow; it is caused by an excess of bile in the liver.

K

kilogram (kĭl′ō-grăm). A measure of weight in the metric system, equal to about two and one fifth pounds in our system.

L

lachrymal gland (lăk′rĭ-mal glănd). The gland in which tears are formed.

lacteals (lăk′tē-alz). The small vessels which carry a milky fluid containing fatty matter from the small intestine.

larynx (lăr′ĭnks). The entrance to the windpipe.

ligaments (lĭg′ȧ-ments). Bands of strong connective tissue which unite bones and form joints.

liver (lĭv′ẽr). The organ, lying near the stomach, which manufactures bile.

longitudinal muscles (lŏn′jĭ-tū′dĭ-nal mŭs″les). Muscles that extend lengthwise with the organ which they move.

lubricated (lū′brĭ-kā-ted). Made smooth or slippery in order to cause movement without grating or friction.

lymph (lĭmf). The part of the blood that leaks from the blood vessels. It contains no red blood corpuscles.

M

maltose (malt′ōs). A crystalline sugar sometimes called *malt sugar*, derived from grains.

massage (măs′āj; F. mȧ′sazh′). A rubbing of the body, done especially as a hygienic or remedial measure.

mastication (măs′tĭ-kā′shŭn). Chewing; as, *mastication* of food.

medulla (mḗ-dŭl'lȧ). An expansion of the upper end of the spinal cord, which controls such reflex acts as breathing and the beating of the heart.

metabolism (mḗ-tăb'ṓ-lĭz'm). The process by which living tissues take up and change the material that the blood brings them for nourishment, or by which they change their own substance into waste matter that can be thrown out of the body.

microbe (mī'krōbe). An organism so small that it cannot be seen by the naked eye.

microscope (mī'krō-skōp or mĭk'rō-skōp). An instrument by which the eye is enabled to see organisms too small to be seen without aid.

molars (mō'lẽrz). Any of the teeth back of the incisors and canines; the teeth used for grinding food.

morphine (môr'fĭn or -fēn). A drug, made from opium, which deadens pain and will put a person to sleep, but which is dangerous.

mucous membrane (mū'kŭs mĕm'brān). The thin layer of tissue lining the passages and cavities of the body.

N

neuron (nū'rŏn). A nerve cell with its branches.

nicotine (nĭk'ṓ-tĭn or -tēn). An element found in tobacco. It is very poisonous.

nitrogen (nī'trṓ-jĕn). A chemical which may be in the form of gas or in the form of liquid.

nitrogenous foods (nī-trŏj'ḗ-nŭs fo͝odz). Foods which contain the substance known as *nitrogen*.

nucleus (nū'klḗ-ŭs). The center of a cell.

nutrient (nū'trĭ-ent). Any food which nourishes.

O

olfactory nerves (ŏl-făk'tṓ-rȳ nẽrvz). The nerves in the nose upon which smell depends.

opium (ō'pĭ-ŭm). The juice of the poppy plant. It is a narcotic poison which may produce sleep or death.

optic nerve (ŏp'tĭk nẽrv). The nerve connecting eye and brain upon which sight depends.

organic (ôr-găn'ĭk). Having organs; alive.
osseous tissue (ŏs'sḗ-ŭs tĭsh'ū̇). Tissue that is like bone; hard tissue.
oxygen (ŏks'ĭ-jĕn). An element necessary to life, which the body takes in from the air.

P

palate (păl'ā̇t). The roof of the mouth.
pancreas (păn'krḗ-as). An organ near the stomach, in which the pancreatic juice is formed to aid in digestion.
papillæ (pȧ-pĭl'lē). Tiny mound-like projections of the skin.
parasite (păr'ȧ-sīt). A plant or animal that lives upon, and gains its nourishment from, the body of another plant or animal.
parietal lobes (pȧ-rī'ḗ-t*a*l lōbz). The round projecting parts of the brain at the sides of the skull.
pelvis (pĕl'vĭs). That part of the body below the stomach, which is made up of the pelvic bones.
pepsin (pĕp'sĭn). One of the fluids composing the gastric juice.
peptone (pĕp'tōn). Fluid which is found in the gastric juice.
periosteum (pĕr'ĭ-ŏs'tḗ-ŭm). The membrane of fibrous connective tissue that covers all bones except at the joints.
peristaltic movement (pĕr'ĭ-stăl'tĭk mōōv'ment). A peculiar worm-like wave motion of the intestines which causes the food to move on.
pestilence (pĕs'tĭ-l*e*ns). The plague, or any terrible fatal disease that spreads easily, rapidly, and widely.
pharynx (făr'ĭnks). The part of the alimentary canal between the mouth and the esophagus.
physique (fĭ-zēk'). The physical build or structure of a person; physical appearance.
plague (plāg). An acute contagious fever, incurable and terrible in its attacks; any disease that destroys many people in a short space of time.
plasma (plăz'mȧ). The fluid part of the blood in which the cells float.
plumb line (plŭm līn). A straight line between two points, as between the forehead and the floor.
posterior chamber (pŏs-tē'rĭ-ĕr chām'bĕr). The inclosed space in the eye behind the lens.
proteid (prō'tḗ-ĭd). One of the elements present in greater or less degree in nearly all plants and to a large degree in animal tissues and organs.

protein (prō'tē-ĭn). One of the class of nutrients which furnishes building material for the body.

ptomaines (tō'mȧ-ĭnz or -ēnz). A class of substances that grow in dead matter; poisons.

pulmonary circulation (pŭl'mō-nā'ry sẽr'kū-lā'shŭn). The movement of the blood as it passes through the heart and the lungs and throughout the body.

pulse (pŭls). The beating of the heart or blood vessels, especially of the arteries at the wrist and in the temple.

pupil (pū'pĭl). The opening of the eye in the center of the iris.

pus (pŭs). A collection of dead white cells in the body.

putrefaction (pū'trē-făk'shŭn). The act of rotting, or decaying.

putrefy (pū'trē-fī). To decay; to rot.

pylorus (pī-lō'rŭs). The opening of the stomach into the intestine.

R

rennin (rĕn'nĭn). One o. tne fluids composing the gastric juice.

respiration (rĕs'pĭ-rā'shŭn). The act of breathing.

retina (rĕt'ĭ-nȧ). The inner coat of the eyeball containing the nerve cells and fibers necessary for sight.

S

saliva (sȧ-lī'vȧ). A fluid found in the mouth and manufactured in the salivary glands; it is necessary for the digestion of starch.

salivary glands (săl'ĭ-vā-rȳ glăndz). Tiny sacs in the lining of the mouth that produce the fluid called *saliva*.

scavenger (skăv'ĕn-jẽr). One who cleans, removes waste, makes conditions healthful by removing dirt and germs.

sclerotic (sklē-rŏt'ĭk). The outer coat of the eye.

sebaceous (sē-bā'shŭs). Composed of fat; containing fat.

secrete (sē-krēt'). To extract from the blood and make into a new substance; as, the salivary glands *secrete* saliva.

sedentary (sĕd'ĕn-tā-rȳ). Inactive physically; requiring much sitting.

septum (sĕp'tŭm). A partition separating the nostrils or nasal cavity into two parts.

serum (sē'rŭm). The pale yellowish fluid that comes out from a clot of blood.

spasmodic (spăz-mŏd'ĭk). Convulsive; irregular; jerky; uneven.

spirometer (spī-rŏm'ē-tẽr). An instrument for measuring the vital capacity of the lungs; that is, the volume of air which can be expelled from the chest after the deepest possible taking in of breath.

sputum (spū'tŭm). Saliva; what is expectorated; spittle.

stagnant (stăg'nant). Not flowing; motionless; impure from want of motion.

sternum (stẽr'nŭm). The breastbone.

stimulus (stĭm'ū-lŭs). Something that rouses to action; as, a *stimulus* to sight or hearing or taste.

stirrup (stẽr'rŭp). One of the three small bones of the ear. It takes its name from its shape.

suspensory ligament (sŭs-pĕn'sō-rў lĭg'à-ment). A suspended or hanging band of connective tissue.

symmetrical (sĭm-mĕt'rĭ-kal). Having one side like another; even; regular.

symmetry (sĭm'mē-trў). Correct proportion or balance of the parts of the body.

T

tannin (tăn'nĭn). A harmful acid found in tea.

temporal lobes (tĕm'pō-ral lōbz). The round projecting parts of the brain at both sides of the skull.

theine (thē'ĭn or -ēn). A poison found in tea and coffee.

thoracic duct (thō-răs'ĭk dŭkt). The great trunk of the lymphatic vessels, between the intestines and the heart.

thorax (thō'răks). The part of the trunk between the neck and the abdomen.

tissue (tĭsh'ū). The fibers that go to make up organs of any sort, as the heart or lungs.

tonsils (tŏn'sĭls). Two organs placed on each side of the throat. They serve to destroy germs on the way to the lungs.

toxin (tŏks'ĭn). A poison; used often in reference to the poisons developed within the body.

trachea (trā'kē-à or trà-kē'a). The windpipe.

tympanic membrane (tĭm-păn'ĭk mĕm'brān). The delicate skin in the ear stretched across the lower end of the canal. It is commonly called the *drum*.

V

ventricle (vĕn′trĭ-k'l). One of the cavities of the heart which forces the blood from the heart into the arteries.

vertebræ (vẽr′tē-brē). Plural of *vertebra*. The small bones that make up the backbone.

villi (vĭl′lī). Plural of *villus*, which is rarely used. The tiny, fine, finger-like projections which cover the lining of the stomach.

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